THE RELATIVE MERITS OF THREE METHODS OF TEACHING GENERAL SCIENCE IN THE HIGH SCHOOL

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Dissertation

THE RELATIVE MERITS OF THREE METHODS OF TEACHING GENERAL SCIENCE IN THE HIGH SCHOOL

A DISSERTATION

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THE RELATIVE MERITS OF THREE METHODS

OF

TEACHING GENERAL SCIENCE

IN THE

HIGH SCHOOL

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W. J. Klopp.

PREFACE

This study represents the results obtained from a controlled experiment covering a period of nine weeks and involving seven hundred pupils taught by sixteen teachers.

The content of the experiment was selected from a standard general science text and included elements in physics, botany, and zoology taught to ninth grade pupils in three senior and three junior high schools of Los Angeles and Huntington Beach.

Since few schools attempt to teach general science by the laboratory method, it was discovered that within the same system as in different systems three methods of teaching were used. In nearly every instance where the Text-Book method was used, it could be found that the teacher was not qualified to use any other method. The lecture method was used by many teachers who were laboring under the urge of "ground to be covered," while the Telling-Demonstration method required too much preparatory work to encourage a wide use of the method. The result of this general investigation together with the analysis of many studies bearing on the problem of method, prompted a study to determine the relative value of the methods under controlled conditions so far as procedure was concerned, but without attempting to classify the groups on the basis of any criterion. It was discovered that all groups were comparable with regard to reading comprehension ability, and the range of I. Q.

Experienced teachers were selected, and the effect of the particular method was measured by objective tests to determine progress achieved on immediate recall and retention.

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THE RELATIVE MERITS OF THREE METHODS OF TEACHING GENERAL SCIENCE IN THE HIGH SCHOOL.

CHAPTER I.

THE PROBLEM.

With the advent of experimental technique and more exact measurement in Education, many of the established ideas of method have been called into question. Amongst others, the methods employed in the teaching of general science have been investigated but as yet no satisfactory or convincing answer, as to the relative merits of any particular method, has been given It was consequently the purpose of the writer to attempt to determine the relative merits of the three most commonly used methods of teaching general science in the high school, viz., the textbook, lecture and telling-demonstration methods.

The process of ascertaining the value of the three methods was by contrasting the progress made by unselected junior and senior high school pupils in each of the three fields of science.

A secondary aim was to determine the effectiveness of the three methods in each of three fields of science content.

A third aim might be stated as an attempt to determine the effectiveness of method, by progress made in each of the three fields of science, by different achievement level groups in terms of both immediate and delayed recall.

And lastly, a fourth but subsidiary aim was to discover whether or not the character of teacher preparation, and experience in teaching a particular branch of science, had any preferential effect upon the nature of the progress made by the pupils in that particular field of study.

CHAPTER II.

REVIEW OF SOME OUTSTANDING EXPERIMENTAL STUDIES ON METHODS OF TEACHING SCIENCE.

Few experimental studies have been made to determine the relative merits of teaching general science by specific methods.

However, since a general science course includes in its content the major fields of science, though not extensively treated, a review of studies made in the fields of biology, physics and chemistry is pertinent in so far as they contributed to experimental technique, and to the measurable effect of method upon progress made by pupils in the high school through the mastery of certain science content.

"Methods of helping pupils to learn prescribed subject-matter are receiving less than one-fifth of the attention given to productive research in the field of education as a whole," says Waples[1].

It is the purpose of this review, therefore, to present the findings of ten of the most outstanding experiments made in order to discover to what extent the relative merits of methods of teaching science in the elementary and secondary schools have been determined. The usual method of a review of this kind involves an analysis of each study in detail, and in a certain historical order, indicating the procedure and technique of each experimenter, and the results of the experiment. The plan of this review purposes to present the findings of each experimenter in the light of certain experimental factors which appear outstanding in some studies and absent in others, and which vary materially in the method of treatment by the experimenters considered. The following is a list of experimental factors found in studies reviewed. (They are not arranged with reference to any order of preference or importance):

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[1]Waples, Douglass, A Technique for Investigations in Classroom *Journal of Educational Research*, April, 1925.

1. Selection and definition of methods;
2. Size and character of groups selected;
3. Methods of determining relative ability of groups;
4. Nature of content selected and manner of treatment;
5. Time devoted to the experiment;
6. Testing and evaluation of test results;
7. Diagnosis of results;
8. Consideration of teacher factor;
9. Summary of findings and conclusion;
10. General conclusions.

In a report on educational research during the years 1920 and 1922, by Baldwin[1], 533 research studies are reviewed, of which only 27 are classified under the head of "Methods of Learning and Teaching." Out of these 27, only three of an experimental character have been selected which on the whole or in part dealt with the problems of the determination of the relative merits of methods of teaching science. The writer is mindful of the fact that such a review must be incomplete if made to the exclusion of other studies in the field, since all others have a distinctive bearing upon certain phases of methods of teaching science. It is the purpose of the review then to deal more critically with the studies of Hunter[2,3], Mayman[4], Knox[5], Wiley[6], Cunningham[7,8], Kiebler and Woody[9], Cooprider[10], Downing[11,12], and Allen[13], since they in their investigations, more nearly conformed to the technique and procedure as indicated by the experimental factors listed above.

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[1]Baldwin, Bird, *Educational Research Bulletin*, No. 42, Washington Government Printing Office, 1923.

[2]Hunter, George, An Experiment in the Use of Three Different Methods of Teaching in the Classroom: *School Science and Mathematics*, Dec., 1921, Jan., 1922, Feb., 1922.

[3]Hunter, George, An Attempt to Determine the Relative Values of Visual and Oral Instruction in Demonstration and Experimental Work in Elementary Biology.

[4]Mayman, J. E., An Experimental Investigation of the Book Method, Experimental Method, Lecture Method of Teaching Elementary Science in Elementary Schools. *Bureau of Educational Research*, 1912, New York City.

[5]Knox, W. W., The Demonstration vs. the Laboratory Method of Teaching High Schoo Chemistry, *School Review*, May, 1927.

[6]Wiley, William H., An Experimental Study of Methods in Teaching High School Chemistry, *Journal of Educational Psychology*, April, 1918.

[7]Cunningham, H. A., Laboratory Methods in Natural Science Teaching. *School Science and Mathematics*, October and November, 1924.

[8]Cunningham, H. A., Under What Conditions is Individual Laboratory Work, in High School Science, preferable, and when does the Lecture Demonstration give better results? *The Proceedings of the High School Conference* of Nov. 18, 19, 20, 1920, University of Illinois.

[9]Kiebler, E. W., and Woody, Clifford, The Individual Laboratory vs. the Demonstration Methods of Teaching Physics, *Journal of Educational Research*, January, 1923.

[10]Cooprider, J. L., Oral vs. Written Instruction and Demonstrations, Individual Work in High School Science. *School Science and Mathematics*, December 1922.

[11]Downing Elliot, Individual Laboratory vs. Teacher Demonstration, *General Science Quarterly*, January, 1927.

[12]Downing, Elliot, A Comparison of Lecture Demonstration and the Laboratory Methods of Instruction in Science, *School Review*, November, 1925.

[13]Allen, I. M., Some Experiments in High School Instruction. *School Review*, January, 1914.

Mention might be made of the contributions made by Anibel[1], Phillips[2], Cureton[3], Holland[4], and Curtis[5].

1. *Selection and definition of methods:* Hunter[6] attempted to test the values of three methods of teaching; the developmental method, the lecture method and the text book method, with respect to immediate recall of memory work and retention, and with respect to the development of power as revealed by pupils' ability to answer questions. Mayman[7] used the lecture, textbook and experimental methods to the same end, but differed from Hunter in general procedure, in using the textbook method by giving mimeographed copies of the materials to be studied to each pupil; and in the experimental method by allowing no comment from pupils, while Hunter solicited pupil discussion, introducing concrete experiences of the pupils. Both Hunter and Mayman used abundant illustrative and supplementary materials in the lecture method but permitted no class discussion or even questions to be asked or answered. In the experimental study of Wiley,[8] the textbook method involved more than a mere study of the typewritten outline of the text by the pupils. Questions were freely asked and answered and the instructor conducted an oral quiz at the close of the period on the salient points of the assignment. This departure by Wiley from the general practice invalidated comparisons with other studies of this special method. He was also more liberal than his contemporaries in the lecture method by allowing class response during the lecture.

The laboratory method, used by Wiley, could hardly be called individual, since generous aid was available from the instructor, and could not be compared with the individual laboratory method described in the experimental studies of Kiebler and Woody,[9] and Cunningham.[10] Theirs were identical in organization but not procedure, and they left the entire task to the pupil to be performed, without teacher-help. In the

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[1]Anibel, Fred G., Effectiveness of Teaching High School Chemistry through Individual Laboratory Experimentation and Lecture Demonstration, Master Thesis, 1924, University of Chicago.

[2]Phillips, Thomas D., "A Study of Notebook and Laboratory Work as an Effective Aid in Science Teaching." *School Review*, 1920.

[3]Cureton, E., Junior High School Science. *School Review*, December, 1927.

[4]Holland, H., Methods of Science Teaching: Tandem and Mixed Systems Composed. *School and Society*, Aug. 14, 1926.

[5]Curtis, Francis, An Investigation of Adults and Children's Scientific Interests. *Teachers' College Record*. No. 32C. 1924.

[6]Op. cit. p. 4.
[7]Op. cit. p. 4.
[8]Op. cit. p. 4.
[9]Op. cit. p. 4.
[10]Op. cit. p. 4.

demonstration method they differed widely. Cunningham adopted the same type of procedure as did Hunter in the lecture method, while Kiebler was assisted by pupils in the entire demonstration and permitted class discussion.

In a more recent study, of the relative values of demonstration and laboratory methods, by Knox, the latter method was distinctly individual in character without teacher-help, while the demonstration method was a purely teacher method.

Six investigators used the demonstration method as one of the methods in the study, while only four used the textbook method. There is a marked contrast between the developmental method of Hunter and the demonstration method of Knox. The former was a pupil-teacher method while the latter a purely teacher method.

The textbook method was described by Hunter as follows: "The pupils quietly studied the assignments given; no questions were asked or answered."

Wiley described the textbook method as follows: "The pupils were told to study the lesson carefully until they felt they knew it. Anything not understood was explained." There are examples of differences in the interpretation of the textbook method. The same variation is found with regard to the lecture and laboratory methods used by the investigators. Three required individual work without aid from the teacher. In the case of Wiley, many questions were asked during the course of the experiments, while in the investigation, by the laboratory method, of Cunningham, pupils were given no help in any experiment

With these differences in procedure with the same methods, practically none of the findings could be considered comparable.

2. *Size and nature of groups selected:* Table I reveals the fact that the range in number of groups selected by the investigators is from 1 to 14, and the number of pupils in the total groups ranged from 24 to 500, selected from 11 grades, beginning with the seventh and ending with college freshman. The number of teachers involved in the studies was not stated by many of the investigators and this was especially true with those dealing with the larger total groups such as were used by Mayman[1] and Hunter.[2]

With one exception, namely, Mayman, the number of groups

[1]Op. cit. p. 4.
[2]Op. cit. p. 4.

used in the study did not exceed four. Six of the studies reported used only two groups, three used three, and one used but one group.

The size of the groups varied from 24 to 500 and no consideration was given to the factor of differentiation of groups. With regard to the teacher factor, there was apparently no consideration given to the number of teachers, their training and experience, as an influencing factor in the investigation.

TABLE I

Size and Nature of Groups and Average Age

Investigator	No. Groups	Average	No. Pupils	No. Teachers	Nature of Groups
Hunter	3	15	90	3	Normal
Hunter	2	.....	90	1	Poor Mentality
Cunningham	2	.....	25	..	H. S. Soph—Normal
Mayman	14	17½	500	..	1-3 Foreign—Av. Ability
Knox	4	15	84	2	Mixed—Normal
Wiley	3	16–20	24	1	Jr.-Sr. H. S. Soph—Normal
Kiebler-Woody	2	.....	60	2	Majority boys—Normal
Cooprider	4	.....	68	1	Soph-mixed—Normal
Cooprider-2	3	.....	42	2	Mixed-Soph—Normal
Allen	1	15.6	30	1	Mixed—Normal
Gilbert	2	same	32	1	28 boys, 4 girls—Normal
Anibal	2	.....	43	1	Normal
Anibal-2	2	.....	34	1	Normal

Table I clearly shows that the results obtained by the investigators could not be compared with a high degree of accuracy owing to the variability of the number and size of the groups; the number of teachers involved, and the general nature of the groups with respect to mental ability and sex.

3. *Method of determining relative group ability:* The factor of relative group ability was taken into account by most of the investigators working with only a few small groups. Mayman[1] and Hunter,[2] working with a larger number of groups, disregarded the factor entirely except that Mayman found each of his groups to have the same grades in physics the preceding semester. Cunningham[3] and Cooprider[4] used both previous average school grades made, and an intelligence test, while Kiebler and Woody[5] and Downing[6] used the intelligence test only. Wiley[7] only used previous grades.

4. *Nature of content selected and manner of treatment:* Eleven experiments were performed in the three major fields of science with five in biology, three in physics and three in chemistry. Cunningham performed two, one in botany and one in chemistry.

[1]Op. cit. p. 4.
[2]Op. cit. p. 4.
[3]Op. cit. p. 4.
[4]Op. cit. p. 4.
[5]Op. cit. p. 4.
[6]Op. cit. p. 4.
[7]Op. cit. p. 4.

The experiment in botany was concerned more directly with the laboratory and demonstration methods of teaching, while the experiment in chemistry involved more specifically a form of technique, viz., the "proverbial" plan directed study. Hunter's two experiments in biology dealt first with the problem of determining the relative merits of three methods of teaching science and secondly with the relative value of visual and oral instruction in demonstration and experimental work.

The manner of treatment of the content selected by each experimenter varied according to the nature of the experiment. In the case of demonstration and laboratory methods, a number of experiments were selected, while in the case of lecture and textbook methods assignments from a given text were made.

Table II shows the fields of science in which the experimental studies were carried on, the methods used and the number of experiments selected from the field of science for the study.

TABLE II.

Showing the field of science, the methods and the number of experiments used by each experimenter.

Investigator	No. Exp.	Content	Methods
Mayman	30	Physics	Book, Developmental, Lecture
Allen	65	Gen. Sci.	Book, Problem
Wiley	3	Chem.	Book, Lecture, Laboratory
Cunningham 1	13	Botany	Laboratory vs. Demonstration
Cunningham 2	12	Botany	Proverbial Plan vs. Directed Study
Hunter	3	Biology	Developmental, Book, Lecture
Hunter 2	4	Biology	Demonstration vs. Laboratory
Cooprider 2	24	Biology	Demonstration vs. Laboratory
Cooprider 2	12	Biology	Demonstration vs. Laboratory
Kiebler & Woody	14	Heat	Demonstration vs. Laboratory
Anibal	25	Biology	Demonstration vs. Laboratory
Knox	10	Chem.	Demonstration vs. Laboratory

It may be noted that there was a wide range, from 3 to 30, in the number of experiments selected and that sixty percent of the experimental studies considered were devoted to a comparative study of the laboratory and demonstration methods.

The selection of material for Hunter's investigation was made from "Richie's Primer of Sanitation" using the following themes or topics for study: "The Relation of Mosquitoes to Yellow Fever and Malaria," and "Other Protozoan Diseases." This constituted the subject matter to be presented by each method to each group and the results obtained formed the

basis for comparison. Mayman confined his study to three fields of science in physics: mechanics, sound and electricity, selecting the "Lever," the "Pendulum," "Condenser" and the law of "Vibrating Strings," as the principal topics for experimental procedure, and gave each topic the same weight with respect to difficulty.

Wiley confined his study to the field of chemistry limiting however his selection to the three special fields of Combustion, Carbon Dioxide, as an agent in Baking Powder and Analine Dyes, practical applications of three principles of chemical action. Cunningham and Knox covered a much wider range in the field of chemistry than did any of their contemporaries, in the selection of the 13 and 14 experiments respectively, selected for their study. As is shown by the table, the selection and general treatment of content in most of the investigations was entirely too limited in scope and in too few cases was the selection representative of the field chosen.

5. *Time devoted to the experiment:* The time factor plays an important role in the effectiveness of a method of teaching, as measured by the amount of progress made in certain prescribed content.

The chief weakness in Hunter's study, according to his own statement, lies in the time devoted to teaching his three groups by each of the three methods. Only one day was taken to apply the three methods, alternating each method with each group thus requiring a total of three days for teaching and testing.

In the words of Mayman, "the investigation, which extended over the spring and fall terms of 1911, included, all told, 30 experiments, of which the experiment-note-book method figured in only 5. The experimenter considered a complete experiment to consist of a comparison of the results obtained by teaching a certain unit of subject matter to several classes, each by a different method, but *all on the same day.*"

Wiley and Cunningham used much the same method of procedure as did Mayman; one recitation period was required for each experiment and the time needed to complete the experiment was noted. This same procedure was followed for each exercise and each method.

Knox scheduled all four of his classes the same part of the school day; the laboratory groups meeting the first and second periods twice a week, and the demonstration groups meeting the

third and fourth periods on the same days. Each group then completed ten experiments by each method in five days, making a total time period of ten days to complete the work by each pair of groups.

It is apparent from the study of their investigations with regard to the time factor, that most of the investigators taught each assignment by a given method to a given group, one period only and tested the results at the close of the same period. The results obtained from this type of procedure must indeed vary with the nature of the experiment, as for example, in the study of Knox, two groups performed ten experiments by one method, while the other two groups were taught the same ten experiments by the demonstration method. By this plan the pupils had an opportunity to become familiar with the technique involved in both methods. Where just one period was devoted to each method in teaching an assignment there was a grave danger of too limited exposure to each of the methods used.

6. *Testing results of the investigations:* Some form of objective test was used by each experimenter to measure immediate recall and retention, where retention was considered. Both Hunter and Mayman tested for memory and power. (Power was interpreted to mean independent thinking and self-reliance).

An essay type of test, consisting of five questions, was used by Mayman at the end of a series of experiments, and again for retention at intervals of seven days, and from forty-four to fifty-five days after the experiments.

The number of correct responses to each of five questions were averaged for each group in each method and the average of the averages compared according to methods used.

Wiley used about the same method of testing by asking the pupils to write out the lesson as they recalled it immediately after the recitation, and followed the same procedure a week and a month later.

Cunningham's plan was unique in that he required his pupils to write up each experiment immediately after it was completed, covering in the report: "What was done," "What happened," and an explanation of "Why it happened." Each pupil's work was then scored on each of these divisions, on a percent basis, on each experiment, including the time required to perform the experiment.

After the groups, in Hunter's experiment, had been taught by a certain method for 20 or 30 minutes, a test was given

consisting of three questions, two testing memory and one power. The relative values of the two parts were then reduced to a percentage basis. Retention was tested after one week's time had elapsed. The Power question was given the same value as the two memory questions.

Objective tests were used by Kiebler and Woody for immediate recall of the facts of the experiment; for retention and for ability to apply principles in attacking new problems. Some of the modern objective tests were used in their testing program.

Knox attempted to test for the same things as did Kiebler and Woody but with different instruments. He used five multiple choice, five completion, five matching and five miscellaneous questions to test results immediately after the experiment.

The test for delayed retention was given three weeks after the completion of the experiments and consisted of four questions selected from each of the ten tests used for immediate retention. Twenty were completion, ten matching, and ten miscellaneous. Knox reduced all scores to Sigma scores for comparison according to methods compared.

7. *Findings of the experimental studies considered and general conclusions:* Very little difference between the experiment method and the lecture method was found by Mayman. In fact, the difference was only 0.16% of the correct responses made in favor of the experiment method and the significance of this difference was not established. Hunter found his developmental method yielding the best results with the lecture method a close second. He found that the memory questions suffered the greatest loss in retention under the book method and the least under the developmental method.

In an analysis of the investigations made by Anibel, Cooprider, Cunningham, Wiley, and Kiebler and Woody, on the relative merits of the laboratory and lecture-demonstration methods, the lecture-demonstration method was found superior to the laboratory method for immediate recall, but for retention, the reverse was found to be true. According to Downing,[1] the difference in every case was so small that the difference in pupil cost, which was estimated to be 14 to 1, was unwarranted. He also found that the cost in time was greater with the laboratory method than the lecture-demonstration method. Coop-

[1]Downing, Elliot, Teaching Science in the Schools, *University of Chicago Press*, 1925.

rider claimed a saving of 50 percent of time by the lecture-demonstration method, and Cunningham found that it took 42 minutes on an average to perform his experiments by the laboratory method as compared with 30 minutes by the demonstration method.

Knox presented the most startling conclusions of the group which are quoted verbatim:

1. "The demonstration method is superior to the laboratory method in teaching mentally heterogeneous groups of pupils for the purpose of immediate retention of subject matter in high-school chemistry.
2. "It is also evident that, when applied to groups of pupils of unequal mental capacity, the demonstration method is better suited for the presentation of information for relatively permanent retention than is the individual laboratory program.
3. "For the purpose of imparting to a group of pupils a scientific attitude and training in a method of attack on new problems, the demonstration method is equal, if not superior, to the laboratory method of instruction.
4. "From the standpoint of the coefficients of correlation, it appears that the demonstration method provides superior opportunity for adaptation to individual differences in mental ability so far as teaching for immediate retention, delayed retention, and method of attack are concerned.
5. "So far as providing knowledge and method of attack are concerned the laboratory method is slightly superior to the demonstration method in the case of the average inferior pupil.
6. "For the purpose of providing knowledge for both immediate retention and relatively permanent retention, and for the purpose of providing a technique for handling new problems, the demonstration method is much to be preferred to the laboratory method in the case of the average superior pupil."

The conclusions regarding the technique and procedure of these investigators may be summarized as follows:

1. With regard to selection and interpretation of methods for experimentation there was too much variation, thus making the findings incomparable between investigators. No two experimenters used the book method alike, and the same was true of the lecture method, and lecture-demonstration method. The demonstration method to some was a purely teacher-problem, to others it was a combination of teacher and pupil problem.

2. Where there was a distinctive differentiation of method, as was the case with Hunter and Wiley, there were too many other variables not considered which affected the results of the investigation, and the significance of the difference in favor of any method was not established by any of the investigators.

3. In every investigation studies (with the exception of Knox) the type content selected in a specific field of science was not dealt with in a representative manner. As for example, in Hunter's study, the pupils were not dealing with biologic ma-

terials, rather materials remotely related to the field of biology, and the same might be said of Mayman in physics, and Wiley in chemistry. Since the investigations purposed to determine the relative merits of science they must have been conscious of the fact that enough representative material was necessary to secure adequate response through interest and effort by each method.

4. No account was taken of pupil and teacher interest with regard to method used and with reference to the field of science in which the study was made, and could not well be considered with the number of groups selected. In fact, the largest group considered was one of 500 boys, and this could not be called unselected if the results are to be considered significant.

The most representative groups, though only four in number, were those selected in the investigation of Knox, who also used the most representative materials. He failed however in ruling out the teacher factor since he used but two teachers.

5. Knox used the sigma scores for comparison of results of his findings with regard to methods used, while the other investigators reduced the scores to percents for comparison. In not a single investigation was progress measured either for immediate recall or retention. Not a single pretest was given to determine the amount of information possessed by the group prior to the experiment. Herein lies the greatest weakness of all the investigations. The merits of methods must of necessity be measured in terms of progress made, and where this was not done, and where the differences in the results were small, the conclusions in favor of any method could hardly be warranted as being significant.

6. One of the most serious errors committed was that of making comparisons of averages, of averages, especially where the averages were made of responses to problems of varying difficulty. This was done in two studies which are quoted by Curtis,[1] Downing,[2] School Review,[3] etc., General Science Quarterly,[4] etc.

7. Finally, the main points of the summary might be briefly stated as follows: The selection of content was too narrow, groups were too small and not representative; methods used

[1]Curtis, F. D., Investigations in the Teaching of Science, p. 30, P. Blakeston & Co., Philadelphia, 1926.
[2]Downing, Roland, Teaching Science in the Schools, pp. 114-117, University of Chicago Press, 1925.
[3]Downing, Roland, *School Review*, November, 1925.
[4]Ibid, *General Science Quarterly*, January, 1927.

varied in their interpretation, and were insufficiently differentiated; tests were not objective; the time factor was too short; the teacher factor was not considered, and the comparative scores were not progress scores; the reliability of the differences of the means of the scores was not established and hence failed to reveal the character of the difference in the use of methods of teaching science, from which the final conclusions were drawn.

CHAPTER III.

TECHNIQUE AND PROCEDURE.

Selection and organization of groups: In an endeavor to establish the relative merits of the lecture, textbook and telling-demonstration methods of teaching general science, twenty-two second semester (A9) classes in general science were selected from six secondary schools, five of which were located in the Los Angeles system and one in the Huntington Beach system. The average number of pupils in each class was 30 with an average age, for boys of 15.2 years, and for girls 15.2 years. The Terman group test of mental ability was given for the purpose of correlation with progress made in each method rather than to establish equal-mentality groups. The Stanford Reading Test was also given for the same purpose.

The classes were divided into three groups, one group for each method used in each unit of botany, physics and zoology. The three groups varied very slightly in mental and reading ability.

Form I shows the arrangement of classes by methods for each unit in each series. In the first column under unit 1 of botany is shown that 8 classes used the lecture method, 8 classes the book method and 6 classes used the demonstration method. Room conditions were noted by each teacher and record made of restlessness of pupils, character of the response, light, heat, conditions of the weather, etc.

Nature of content and manner of treatment: In view of the fact that no experiments on methods had been performed with large groups in more than one specific field of science, and in order not to interfere with the general plan of the classes involved to comply with the course of study as prescribed by the city, three types of science material were taken from the revised edition of Snyder's book on general science. This book was in use in both the Los Angeles and Huntington Beach schools and hence was available for all classes alike.

ORDER OF PROCEDURE OF CLASSES BY METHODS

Class	Series I Botany Methods I	II	III	Series II Physics Methods I	II	III	Series III Zoology Methods I	II	III
1	L	B	D	B	D	L	D	L	B
2	L	D	B	D	B	L	B	L	D
3	B	D	L	D	L	B	L	B	D
4	B	L	D	L	D	B	D	B	L
5	D	L	B	L	B	D	B	D	L
6	D	B	L	B	L	D	L	D	B
7	L	B	D	B	D	L	D	L	B
8	L	D	B	D	B	L	B	L	D
9	B	D	L	D	L	B	L	B	D
10	B	L	D	L	D	B	D	B	L
11	D	L	B	L	B	D	B	D	L
12	D	B	L	B	L	D	L	D	B
13	L	B	D	B	D	L	D	L	B
14	L	D	B	D	B	L	B	L	D
15	B	D	L	D	L	B	L	B	D
16	B	L	D	L	D	B	D	B	L
17	D	L	B	L	B	D	B	D	L
18	D	B	L	B	L	D	L	D	B
19	L	B	D	B	D	L	D	L	B
20	L	D	B	D	B	L	B	L	D
21	B	D	L	D	L	B	L	B	D
22	B	L	D	L	D	B	D	B	L

B—Textbook. L—Lecture D—Telling-Demonstration

The three types of content selected from Snyder's text were: botany, physics and zoology. Each type was further divided into three more or less equivalent units. The primary purpose of the subdivision into units was to afford an opportunity to teach each group by each method in each of the three fields of science. By this plan it was possible to obviate both pupil and teacher preference in any particular field. Each unit was then divided into three assignments, making in all nine units and twenty-seven assignments. Botany was designated as Series I; Physics as Series II, and Zoology as Series III. Each series was further divided into Units I, II and III.

The three assignments, for each unit of each series, were outlined for each teacher and written instructions were given to each teacher in order to insure uniformity of procedure in teaching the prescribed content according to the method assigned.

Selection and definition of methods: The three methods selected for the investigation were the textbook, lecture and telling-demonstration methods. Since it is not in accordance with current practice to teach general science by the laboratory method, this method was not considered in the study.

Each method was defined and submitted to each teacher at the beginning of the study so as to insure, so far as possible, uniformity in method of teaching of all the groups.

Instructions to teachers with regard to the nature and character of the method to be used in the unit assignment were given for each method.

The writer justifies the selection of the three methods from two points of view: first, because of current practice in high schools in which he has had an opportunity to observe the work of experienced teachers; and secondly because of the attempts made by many investigators to determine the relative values of the three methods of teaching general science by experimentation with classes in the public schools.

While the telling-demonstration method bears a somewhat different label in this study from that of other studies, it agrees very closely in its operation with the developmental method of Hunter, and the lecture-demonstration method of Knox, in his study. The lecture method was defined to agree with current practice in teaching general science in the junior and senior high schools.

Time factor and procedure: On the first day, half of the period was spent in explaining the nature of the experiment to the pupils so as to cultivate their cooperation. Nothing was said with regard to the attempt to show the comparative results of methods used. The second half of the period was given over to a pre-test or initial test covering the assignment for the following three days. On the fifth day following, the first half of the period was devoted to testing the results of the previous three days' teaching, and the last half of the period to initial testing for the succeeding three days' assignments. Nine weeks were required to complete the study. Three weeks for each series of assignment and one week for each of the three units of the series were required.

In the event of a holiday or class interruption, through special days in school (factors which could not be foreseen) the work proceeded the following day as before. Few interruptions were experienced in the investigation except during the Christmas holidays and these were adjusted without injury to the experiment. All groups completed the third series of the experiment

before the Christmas holidays except two, which lacked one unit of the last series.

The retention tests for all groups were given at intervals of three weeks except the interval including the holiday which covered a period of four weeks. This affected only the second unit of the last series.

Testing and measuring results: Objective tests were given to each group before and after the assignment of each unit. As for example: In the first unit of botany, an initial test was given immediately after the assignment had been completed. The same procedure was followed for each succeeding unit in each series.

Objective tests, similar in kind, were used consisting of twenty-five half completion and half best-answer questions, with a value of one assigned to each correct response to the question, making a total of twenty-five possible responses for the test, except for the first unit of botany in which the test had a possible total score of thirty-five responses.

The coefficient of correlation between the initial and final tests was established by giving both tests to a group of one hundred pupils in a high school who had completed the work of the science material, of which the test was composed. The measure of reliability of the two tests was found for the tests of each of the three series of content, botany, physics and zoology, and the results were as follows:

Botany	$r = 0.66 \pm .05$	Brown's formula 0.79
Physics	$r = 0.63 \pm .07$	Brown's formula 0.77
Zoology	$r = 0.58 \pm .04$	Brown's formula 0.73

The results show that the correlation is significant since in each field of science the probable error is small and the coefficient is much more than four times the probable error[1].

According to Brown's formula for doubling the number of elements in a test to increase the reliability coefficient, the correlation for botany is increased from 0.66 to 0.79; for physics from 0.63 to 0.77 and for zoology from 0.58 to 0.73. The formula used was $r_x = \frac{Nr}{1+(N-1)r}^2$, when N was 2, r the coefficient of correlation and r_x; the increased coefficient of correlation.

[1]Garrett, Henry E., Statistics in Psychology and Education, Longmans, Green and Co., 1926, p. 170.

[2]Brown, Wm., The Essentials of Mental Measurement, 1911, p. 102.

In the construction of the initial and final tests, those elements were selected which were more directly interpretable according to the ability of the child, leaving for the final test those elements of a more technical character which it is possible for the child to master by the aid of instruction. This then would be measuring progress according to the method used and the ability of the child to gain added information by means of the method employed.

CHAPTER IV.

EXPERIMENTAL RESULTS.

Selection and use of measures for comparison: For this study the raw scores were changed to per cent scores and the mean score in per cent was calculated for each method in each unit together with its probable error. The following formula was used to determine the PE of the mean:

$$\text{PE (av.)} = \frac{0.67450\delta \text{ (dis.)}}{\sqrt{\text{N}}}$$

For the determination of the significance of the difference of the two measures, which after all was necessary in an attempt to show the significance of the difference of the mean scores, the probable error of the difference seemed most valuable.

$$\text{PE (difference)} = \sqrt{\text{PE}^2 \text{ (av. 1)} + \text{PE}^2 \text{ (av. 2)}}$$

To show the relationship between results obtained by a group in two different situations the Pearson product moment formula was used.

$$r = \frac{\frac{\sum x'y'}{\text{N}} - c_x c_y}{\delta_x \delta_y}.$$

$\sum x'y'$ represents the summation of the product of the deviation from the guessed mean, and c_x, c_y the correction factors from the guessed mean for the x and y distributions. x and y represent the standard deviations of each distribution. The probable error of r was determined by the formula:

$$\text{PE}_r = \frac{.6745\,(1-r^2)}{\sqrt{\text{N}}}.$$

The Meaning of Progress: Many investigators have attempted to show that a difference of the final scores made by certain groups taught by different methods was sufficient to justify their conclusions. Whether they were justified or not is not the purpose of this study but it appears that such a com-

parison, whether the difference is large or small, is unreliable since the final score of any pupil includes all that which he knew before exposure to the content plus what he learned during exposure. For example: A child may have abundance of information on a certain subject assigned as a unit in the experiment, and could learn little more by some process of instruction, while another child might know little about the same unit and gain much by a certain method of teaching.

In order then to find a factor for use in determining, by comparison, the relative merits of certain methods of science, a progress score was adopted. This progress score was derived from the difference between the final score and the initial score made by the child before and after the completion of the assignment in each unit of content. In the same manner the retention-progress scores were determined, by subtracting the initial scores from the final scores made in the delayed test (retention test). This factor seems somewhat misleading. The meaning it intends to convey is the relative ability to retain more of the content when taught by one method than by another.

Comparison of Methods in the Three Units of Botany.

Comparison of methods in the first unit of botany: "Dr. Myers, at the London County Council Teachers' Conference, 1912, gave the advice 'Beware of the Average'. Another psychologist to whom this was quoted retorted, 'Yes, but distrust totally anything which is not an average.' "[1]

The comparison of progress scores for the book, lecture and demonstration methods, as applied in the first unit of botany, is made through the use of data on measures of initial, final and progress scores presented in the following table.

The data of Table III on the progress of pupils, as shown in the contrast of methods, indicate that the amounts of progress in the first unit of botany for the lecture and book methods were approximately equal and that progress for the demonstration method was obviously greater than that of the other two methods.

When final scores are used there is a noticeable difference in progress made by pupils in the lecture and book and lecture and demonstration methods in which the lecture method is significantly superior to the two. The amounts of progress

[1]Webb, Edward, Character and Intelligence, *British Journal of Psychology*, Monograph Supplements Vol. 1, 1915.

made for the demonstration and book methods is approximately equal.

Thus it seems that the order of rank of method in terms of progress made, would be lecture, demonstration, book.

Comparison of methods in the first unit of botany: The comparison of retention-progress scores for the book, lecture, and demonstration methods, as applied in the first unit of botany, is made through the use of the data on measures of initial retention and retention-progress scores presented in the following table:

TABLE III

Showing the comparison of methods in the First Unit of Botany as to mean progress scores achieved.

		Mean Progress Score		Mean Final Scores	Contrast		
No. Cases	Method	M	PE_M	M	Diff. of Means	Diff. / PE_D	Prob. >0
159	B	36.7	± .9	61.2	L-B 2.0	1.5	84 out of 100
94	L	38.7	±1.1	65.2	D-L 1.6	1.1	77 out of 100
154	D	40.3	±1.0	62.1	D-B 3.6	2.8	97 out of 100

The table should be read as follows: The 159 cases taught by the book method made a mean score of 36.7 while the 154 cases taught by the demonstration method made a mean score of 40.3; the superiority of the demonstration method over the lecture method is 1.6 and the true difference is 1.1 which leads to a probability that the demonstration method excels by 77 out of 100.

The data of Table IV on the retention-progress of pupils as shown by one of the several methods rather than another, indicate that the amounts of retention-progress in the first unit of botany for the lecture method was obviously greater than for the book method, the difference being reliable, while it was approximately equal to that of the demonstration method. The progress made by the demonstration method was definitely superior to that of the book method.

In consideration of the difference of methods by retention scores the superiority of the lecture method over the other two is definitely established and the difference between the demonstration and book methods shows a preference in favor of the former.

We find therefore with regard to retention-progress that the order of rank of methods would be: Lecture, demonstration, book.

TABLE IV

Showing the comparison of methods in the First Unit of Botany as to mean retention-progress scores achieved.

No. Cases	Method	Mean Retention Scores M	Mean Retention Progress Scores M	PE	Contrast Diff. of Means	Diff. / PE$_D$	Prob. >0
159	B	59.5	35.0	± .9	L-B 6.4	4.4	99 out of 100
94	L	67.9	41.4	±1.2	L-D 1.1	0.8	69 out of 100
154	D	62.0	40.3	± .9	D-B 5.3	1.2	77 out of 100

The table should be read as follows: The 159 cases of retention scores by the book method show a mean score of 59.5 and of retention-progress scores a mean of 35.0 with a PE of .9. The superiority of the lecture method over the book method is 6.4 which leads to a probability that the lecture method excels in 99 cases out of 100.

TABLE V

Showing the comparison of lecture, demonstration and book methods for the First Unit of Botany by the percentile, final and progress scores.

Comparison of methods in terms of percentile, final and progress scores.

		Final					Progress				
Meth.	N	Med.	P10	P90	P25	P75	Med.	P10	P90	P25	P75
B	159	63.2	44.7	82.9	50.76	73.1	35.89	14.9	57.67	24.9	49.75
L	94	65.2	45.7	84.8	53.4	76.3	40.4	17.8	60.5	26.8	51.7
D	154	64.1	32.2	85.3	49.4	74.3	40.	18.	64.7	26.9	54.4

For the lower ten per cent of the progress scores the demonstration method seems to be noticeably better than the book method and approximately equal in value to the lecture method.

For the upper ten per cent the demonstration method is obviously superior to the other two and the lecture and book methods are approximately equal in value.

In consideration of the final scores the lecture method is superior to the demonstration method and approximately equal to the book method for the lower decile and quartile.

For the upper decile the demonstration method is obviously superior to the other two. For the lower decile and quartile the book method is noticeably superior to the demonstration method.

For the lower ten and twenty-five per cent in the retention-progress scores the lecture method is approximately equal to the demonstration method and obviously superior to the book

method. For the seventy-five and ninety per cent the lecture method is inferior to the demonstration method and superior to the book method.

TABLE VI

Showing the comparison of lecture, demonstration and book methods for the First Unit of Botany by the percentile, retention and retention-progress scores.

Comparison of methods in terms of percentile, retention and retention-progress scores.											
		Retention					Retention-Progress				
Meth.	N	Med.	P10	P90	P25	P75	Med.	P10	P90	P25	P75
B	159	62.1	38.9	80.9	50.2	71.56	35.15	12.8	59.3	24.5	47.4
L	94	69.6	48.	88.8	58.7	81.5	40.9	20.2	60.15	30.8	53.4
D	154	62.4	43.8	83.	51.8	71.7	40.3	19.6	64.1	28.5	51.8

In consideration of the retention scores the lecture method excels the other methods in all the percentile scores recorded and for the 50, 25 and 75 per cents the demonstration and book methods are approximately of equal worth.

Comparison of methods used in the second unit of botany: The comparison of progress scores for the book, lecture and demonstration methods, as applied in the second unit of botany, is made through the use of the data on measures of final, and progress scores presented in the following table.

TABLE VII

Showing the comparison of methods in the Second Unit of Botany as to mean progress achieved.

		Mean Final Scores	Mean Progress Scores		Contrast		
Meth.	N	M	M	PE	Diff. of Means	Diff. / PE$_D$	Prob. D > 0
B	83	63.0	38.9	±1.1	B-L 5.1	3.6	99 out of 100
L	144	53.0	33.8	±0.9	D-L 7.2	5.6	99 out of 100
D	158	62.0	41.0	±1.0	D-B 2.2	1.4	67 out of 100

The table should be read as follows: The 83 cases of final scores for the book method show a mean score of 63.0 and a mean progress score of 38.9; the superiority of the book method over the lecture method, 5.1, with a true difference of 3.6; which leads to a probability that the lecture method excels the book method in more than 99 cases out of a 100.

The data of Table VII on the progress of pupils as shown by one of the several methods rather than another indicate that the amounts of progress in the second unit of botany for the demonstration and book methods is approximately equal and that both excel the lecture method with statistical certainty.

When the final scores are employed for comparison of methods the lecture method is found to be inferior to both the book and demonstration methods and that the book and demonstration methods show equal progress. The order of rank of method with regard to progress would be: Demonstration, book, lecture.

Comparison of methods used in the second unit of botany: The comparison of progress scores for the book, lecture, and demonstration methods, as applied in the second unit of botany, is made through the use of the data in measures of retention, and retention-progress scores presented in the following table.

TABLE VIII

Showing the comparison of methods in the Second Unit of Botany as to the mean retention-progress achieved.

		Retention	Retention-Progress		Contrast		
Meth.	N	M	M	PE	Diff. of Means	Diff. / PE$_D$	Prob. D>0
B	83	55.9	31.8	±1.1	B-L 1.1	0.9	72 out of 100
L	144	50.0	30.7	±0.7	D-L 3.6	3.8	99 out of 100
D	158	55.3	34.3	±0.8	D-B 2.5	1.8	89 out of 100

The table should be read as follows: The 83 cases of retention scores for the book method show a mean score of 55.9 and a mean score of 31.8 for retention-progress; the superiority of the book method over the lecture method, 1.1 with a true difference of 0.9; which leads to a probability that the book method excels the lecture method in more than 72 cases out of 100.

The data of Table VIII on the retention and retention-progress of pupils, as shown by one of the several methods rather than another, indicate that the amounts of retention-progress in the second unit of botany for the book and lecture methods were approximately equal, and that each was obviously inferior to the demonstration method. The superiority of the demonstration method over the other two is established with certainty.

In considering the retention scores for comparison of methods the superiority of the book method over the lecture method is certain, whereas the demonstration and lecture methods were approximately equal.

The order of rank of methods with regard to retention-progress in the second unit of botany is as follows: Demonstration, book, lecture. With regard to retention the order of method is: Book first, demonstration second, and lecture last.

For the lower and upper deciles the book and demonstration methods are approximately of equal worth and both superior to

the lecture method. The demonstration method is obviously superior to the other two in the upper decile.

In consideration of the percentile final scores the lecture method is inferior to the other two methods. The demonstration method is superior to both methods in the fifty and seventy-fifth percentiles.

In terms of progress as indicated by percentile scores the order of rank of method is: Demonstration, book, lecture for the median (90 and P75). For P10 and P25 the order is as follows: Book, demonstration, lecture.

The demonstration method excels the other methods in all the percentile retention-progress scores by a small difference, and the book method is markedly better than the lecture method in every percentile except the twenty-fifth.

In consideration of the percentile retention scores the book and demonstration methods are approximately equal in value in the median, 25 and 75 per cents and both definitely superior to the lecture method.

TABLE IX

Showing the comparison of lecture, demonstration and book methods for the Second Unit of Botany by the percentile, final and progress scores.

		Comparison of methods in terms of percentile, final and progress scores.									
Meth.	N	Med.	P10	P90	P25	P75	Med.	P10	P90	P25	P75
B	83	62.9	40.3	85.9	53.1	73.8	38.7	17.8	62.1	31.1	49.5
L	144	53.0	33.5	74.9	42.4	66.3	33.5	13.8	54.4	23.8	45.4
D	158	64.3	41.3	83.3	50.7	75.2	41.7	16.5	62.8	28.4	54.6

TABLE X

Showing the comparison of lecture, demonstration and book methods for the Second Unit of Botany by the percentile, retention and retention-progress scores.

		Retention					Retention-Progress				
Meth.	N	Med.	P10	P90	P25	P75	Med.	P10	P90	P25	P75
B	83	57.5	40.2	76.1	47.1	64.3	31.7	15.2	53.1	22.1	43.5
L	144	51.3	33.2	68.3	41.6	60.8	30.2	13.9	50.4	22.3	39.4
D	158	57.2	37.2	69.6	47.3	65.7	33.7	17.1	53.7	24.1	44.3

Comparison of methods used in the third unit of botany: The comparison of progress scores for the book, lecture, and demonstration methods, as applied in the third unit of botany, is made through the use of the data on measures of initial, final, and progress scores presented in the following table.

The data of Table XI on the progress of pupils as shown by one of several methods rather than another indicate the amounts

of progress in the third unit of botany varied for all methods and favoring with statistical certainty the lecture method over both the other methods. The book method in the third unit of botany is obviously inferior to the other two methods.

TABLE XI

Showing the comparison of methods in the Third Unit of Botany as to mean progress achieved.

		Final	Progress	Contrast		
Method	N	M_F	M PE	Diff. of Means	Diff. / PE_D	Prob. D>0
B	160	56.8	23.0±0.9	L-B 7.1	5.4	99 in 100
L	146	64.7	30.1±1.0	L-B 3.8	2.3	94 in 100
D	93	62.3	26.4±1.3	D-B 3.3	2.1	92 in 100

The table should be read as follows: The 160 cases of final scores for the book method show a mean score of 56.8 and a mean progress score of 23.0; the superiority of the lecture method over the book method, 7.1, with a true difference of 5.4; which leads to a probability that the lecture method excels the book method in more than 99 cases out of a 100.

When the final scores are observed the order of rank of methods appears to give the lecture method first place and the book method third. This order consistently follows in the progress scores.

Comparison of methods used in the third unit of botany: The comparison of the retention-progress scores for the book, lecture, and demonstration methods, as applied in the third unit of botany, is made through the use of data on measures of retention, and retention-progress presented in the following table:

TABLE XII

Showing the comparison of methods in the Third Unit of Botany as to mean progress achieved.

		Retention	Retention-Progress		Contrast		
Meth.	N	M_F	M_P	PE_M	Diff. of Means	Diff. / PE_D	Prob. D>0
B	160	53.4	19.7±0.9		L-B 1.0	1.6	89 out of 100
L	146	55.2	20.7±1.1		D-L 0.2	0.9	73 out of 100
D	93	56.4	20.5±1.1		D-B 0.8	2.4	95 out of 100

The table should be read as follows: The 160 cases of retention scores for the book method show a mean score of 53.4 and of retention-progress 19.7; the superiority of the lecture method over the book method is 1.0, with a true difference of 1.6; which leads to a probability that the lecture method excels the book method in more than 89 cases out of 100.

The data of Table XII shows for retention-progress the three methods to be of approximately equal worth with a slight pref-

erence for the lecture method over the other two and with the book method ranking third place.

In regard to the retention scores as a basis for comparison of methods the lecture and demonstration methods are approximately of equal value and both superior to the book method with statistical certainty.

For the lower ten per cent in the progress scores the book method is superior to the other methods and the lecture method excels the demonstration method with certainty. For the 90, 25, and 75 per cents the lecture method is superior to the other two methods and the demonstration excels the book method. In consideration of the percentile final scores the lecture and demonstration methods are of approximately equal worth and both are superior to the book method.

The three methods appear to be of equal worth in all the percentile retention-progress scores, favoring slightly the lecture method in the upper quartile and the median, and favoring the demonstration method in the lower decile and quartile.

In the retention scores the lecture method appears superior to the other two methods in the upper quartile and decile while the demonstration method excels over the other two in the lower quartile and decile.

TABLE XIII

Showing the comparison of lecture, demonstration and book methods for the Third Unit of Botany by the percentile, final and progress scores.

Comparison of methods in terms of percentile, final and progress scores.											
		Final					Progress				
Meth.	N	Med.	P10	P90	P25	P75	Med.	P10	P90	P25	P75
B	160	58.5	39.0	76.5	45.0	68.2	23.1	7.8	44.7	10.1	37.0
L	146	66.4	43.6	82.1	57.2	76.0	30.0	6.1	55.3	18.0	42.9
D	93	62.3	43.5	82.4	53.9	72.9	25.3	2.4	52.1	13.5	41.4

TABLE XIV

Showing the comparison of lecture, demonstration and book methods for the Third Unit of Botany by the percentile, retention and retention-progress scores.

Comparison of methods in terms of percentile, retention and retention-progress scores.											
Meth.	N	Med.	P10	P90	P25	P75	Med.	P10	P90	P25	P75
B	160	56.1	30.0	72.8	43.1	64.5	21.5	.0	42.0	6.4	32.7
L	146	57.6	36.4	74.1	44.1	66.0	22.1	1.7	40.7	6.6	34.5
D	93	58.0	39.3	73.6	46.4	65.4	21.5	0.6	41.9	10.2	32.7

Summary of the findings of series one, botany, with regard to the results of the three methods of teaching: Table XV shows the rela-

tive ranking of each of the three methods in each unit of botany for all the test scores and the progress scores derived from them. Tables XVI, XVII and XVIII, show the relative ranking of the three methods by percentile scores in all the tests and the progress scores derived from them.

TABLE XV

Summary table showing the order of rank of method in the Three Units of Botany for all test scores and their resulting progress scores.

Tests	Unit I	Unit II	Unit III
Initial	L-B-D	B-D-L	D-L-B
Final	L-D-B	B-D-L	L-D-B
Progress	D-L-B	D-B-L	L-D-B
Retention	L-D-B	B-D-L	D-L-B
Retention Progress	L-D-B	D-B-L	L-D-B

TABLE XVI

Summary table showing the order of rank of method in the First Unit of Botany with regard to percentile scores in each test and the resulting progress scores.

	Unit I				
Tests	Med.	P10	P25	P75	P90
Initial	L-B-D	L-B-D	L-B-D	L-B-D	L-D-B
Final	L-D-B	L-B-D	L-B-D	L-B-D	D-L-B
Progress	L-D-B	D-L-B	D-L-B	D-L-B	D-L-B
Retention	L-D-B	L-D-B	L-D-B	L-D-B	L-D-B
Retention-Progress	L-D-B	L-D-B	L-D-B	L-D-B	D-L-B

TABLE XVII

Summary table showing the order of rank of method in the Second Unit of Botany with regard to the percentile scores, in each test and the resulting progress scores.

	Unit II				
Tests	Med.	P10	P25	P75	P90
Initial	B-L-D	D-B-L	D-B-L	D-L-B	L-D-B
Final	L-D-B	L-D-B	L-D-B	L-D-B	D-L-B
Progress	L-D-B	B-L-D	L-D-B	L-D-B	L-D-B
Retention	D-L-B	D-L-B	D-L-B	L-D-B	L-D-B
Retention-Progress	L-D-B	D-B-L	D-B-L	L-B-D	B-D-L

TABLE XVIII

Summary table showing the order of rank of method in the Third Unit of Botany with regard to the percentile scores, in each test and the resulting progress scores.

	Unit III				
Tests	Med.	P10	P25	P75	P90
Initial	D-L-B	D-B-L	D-B-L	D-L-B	L-D-B
Final	L-D-B	L-D-B	L-D-B	L-D-B	D-L-B
Progress	L-D-B	B-L-D	L-D-B	L-D-B	L-D-B
Retention	D-L-B	D-L-B	D-L-B	L-D-B	L-D-B
Retention-Progress	L-D-B	D-B-L	D-B-L	L-B-D	B-D-L

In summary table XV the order of rank of methods in the three units is changed for each unit in the initial test while in the final test the lecture ranks first in the first and third units and the book method first in the second unit. In the progress scores the demonstration method ranks first both in the first and second units and second in the third unit, and in retention-progress it ranks first in the second unit and second in the first unit and third unit. In the progress scores of the first unit the advantages of the demonstration method over the lecture method is only slightly significant while in the second unit it is statistically significant and in the third unit the lecture method is favored significantly. In the final scores the lecture method is superior to the demonstration method in the first and third units with a significance of 94 out of 100 and 91 out of 100 chances respectively, that the difference is greater than zero, while in the second unit the demonstration is superior to the lecture method with a significance of complete certainty.

In the final scores the advantage of the lecture method over the book method is significant in the first and third units. In the second unit the book method is markedly supperior to the lecture method.

The chances are 84 to 100 that the lecture method is superior to the book method in the progress scores of the first unit and with statistical certainty that it is superior in the third unit. But in the second unit the book method is superior to the lecture method. In both final and progress scores do we find the demonstration method superior to the book method except in the second unit where the reverse is true.

Retention and retention-progress scores for the three units of botany: The lecture method has a very significant advantage over the book method in the retention and retention-progress scores of the first unit, and a distinct advantage over the demonstration method in the retention scores, but only a slight advantage in the retention-progress scores of the first unit. The demonstration method has a significant advantage over the book method in the retention-progress scores and a slight advantage in the retention scores, of the first unit of botany. In the second unit, the situation takes on a different form. Here the book method is quite as superior to the lecture method as the demonstration is to the lecture method, hence the difference between the book and demonstration methods is quite unreliable in the retention tests. In the retention-progress test there is a slight

difference between the book and lecture methods in favor of the book method, and a small difference between the book and demonstration methods in favor of the demonstration method. In the third unit there appears to be very little difference between the three methods in the retention-progress test, none of which are significant although the lecture method is favored over the book and the demonstration methods, and the demonstration method is favored over the book method.

Discussion of summary tables XVI, XVII and XVIII, relative to percentile scores for each of the three methods: Median Group: Table XV shows that the lecture method ranks first in the first unit of botany for all tests except the progress tests where the demonstration method ranked first. In the second unit of botany the book method ranked first in each test except the progress and retention progress tests in which the demonstration method was superior. It is of value to note that pupils made most progress by the demonstration method in the first and second units of botany than by the other two methods but in the third unit pupils succeeded better by the lecture method than by either of the other two. In making a cross analysis of pupil success as measured by rank of method in the three units of botany we find that pupils made most progress by the demonstration method but retained less of it than did the pupils who were taught by the lecture method.

Lecture, Demonstration, Book. P10 Group. The rank of methods in the lower decile with regard to superiority is as follows: Demonstration, lecture and book, for all three units. This is considering all test and progress scores derived from them.

P25 Group. The rank of method in this group and for all tests in the three units is a tie for the lecture and demonstration methods both having six first and three for the book method.

P75 Group. The rank of method in this group is as follows: Lecture, demonstration and book.

P90 Group. The rank of method in this group is lecture, demonstration, and book.

Summary horizontally: Considering the results of the methods by the percentile scores in the final tests and progress scores, and retention and retention-progress scores, horizontally, we find in the final test scores the lecture method to be consistently first except in the 90th percentile while the demonstration method is consistently first in the progress scores except in the median. In both the retention and retention-progress scores the lecture

method appears to be first except in the 90 percentile of the retention-progress scores. Where the lecture method is first, the demonstration method is nearly always second, and vice versa, this is true in particular in the first unit and in the progress, retention and retention-progress scores, but not entirely true in the initial and final scores.

The demonstration method is consistently first in the second unit in the retention-progress and progress scores for the 10th and 25th percentiles. In the third unit the lecture method is first except in the upper decile of the final scores and first in the progress scores except in the lower decile. The lower decile and quartile favors the demonstration method in the retention-progress scores while the lecture method appears to be superior in the upper quartile and the book method in the upper decile. One might conclude from the findings that for the upper groups above the 75th percentile, the lecture method seems to be superior to the other two and for the lower groups in the lower quartile the demonstration method seems superior.

Summary of the series, botany, in terms of the order of rank of methods for the combined units for all tests and progress scores. Table XIX shows no preferential difference in the ranking of methods with reference to retention scores. The lecture method excels in the final scores while the demonstration method ranks first in the progress and retention-progress scores. If any value can be attached to the total preferences for all tests and progress score ranking there appears to be equal value assigned to the lecture and demonstration methods, and both are decidedly superior to the book method. The book method appears to have no status whatsoever in botany with regard to progress and retention-progress ranking.

TABLE XIX

Showing the order of rank of method for the Three Units of Botany by frequency of rank in each test and the progress scores derived from the tests.

Method.	Final	Progress	Retention	Retention-Progress	Total Preference
D	0	2	1	2	5
L	2	1	1	1	5
B	1	0	1	0	2

In consideration of the order of rank of methods in percentile scores for all tests and progress scores there is much greater varia-

tion in the order of preference. For the lowest and highest percentiles the demonstration method is obviously superior. In the upper quartile the lecture method held first place and in the lower quartile equal value is assigned to the lecture and demonstration methods, while in the fifty percentile, the lecture method excels. The book method holds third rank in every percentile in the first series.

TABLE XX

Showing the order of rank of methods by percentiles final, progress, retention and retention-progress scores in Botany.

Percentiles	Meth.	Final	Progress	Retention	Retention-Progress	Total Preference
P10	D	1	1	1	2	5
	L	2	0	1	1	4
	B	0	2	1	0	3
P25	D	0	1	2	2	5
	L	2	1	1	1	5
	B	1	1	0	0	2
Med.	D	1	1	2	1	5
	L	2	2	1	2	7
	B	0	0	0	0	0
P75	D	0	2	1	1	4
	L	2	1	2	2	7
	B	1	0	0	0	1
P90	D	2	2	0	2	6
	L	0	1	2	0	3
	B	1	0	1	1	3

COMPARISON OF METHODS IN THE THREE UNITS OF PHYSICS.

Comparison of methods used in the first unit of physics: The comparison of progress scores for the book, lecture, and demonstration methods, as applied in the first unit of physics, is made through the use of data on measures of initial, final, and progress scores presented in Table XXI.

The data of Table XXI on the progress of pupils as shown by one of several methods rather than another, indicate that the amount of progress in the first unit of physics, by the demonstration method as compared with that of the lecture and book methods, is obviously superior. Progress by the lecture method is markedly superior to that of the book method. Hence with regard to progress in the first unit of physics the demonstration method ranks first and the book method third.

When the final scores are employed as the basis for comparing methods the superiority of the *demonstration method over the*

other two is established with statistical certainty and the lecture method excels the book method with the same degree of certainty.

The final scores would give the same order of rank of methods as the progress scores viz; the demonstration method first and the book method third.

TABLE XXI

Showing the comparison of methods in the First Unit of Physics as to mean progress achieved.

		Final	Progress		Contrast		
Method	N	M	M	PE_M	Diff. of Means	Diff. / PE_D	Prob. D>0
B	59	53.8	29.02	±1.2	L-B 8.8	5.9	99 in 100
L	174	58.7	37.9	±0.9	D-L 9.5	8.	99 in 100
D	151	65.6	47.4	±0.8	D-B 18.4	12.6	99 in 100

The table should be read as follows: The 59 cases of Final scores of the book method show a mean score of 53.8 and the mean of the Progress score of 29.02. The superiority of the lecture method over the book method, 8.8, with a true difference of 5.9 which leads to a probability that the lecture method excels the book method in more than 99 cases out of a 100.

Comparison of methods used in the first unit of physics: The comparison of retention-progress scores for the book, lecture, and demonstration methods, as applied in the first unit of physics, is made through the use of the data on measures of initial, retention and retention-progress scores presented in Table XXII.

TABLE XXII

Showing the comparison of methods in the First Unit of Physics as to mean progress achieved.

		Reten-tion	Retention-Progress		Contrast		
Meth.	N	M	M	PE	Diff. of Means	Diff. / PE_D	Prob. D>0
B	59	59.1	34.3	±1.2	L-B 2.7	1.7	87 in 100
L	174	52.9	37.0	±1.0	D-L 10.6	8.2	99 in 100
D	151	65.8	47.6	±0.9	D-B 13.3	8.9	99 in 100

The table should be read as follows: The 59 cases of retention scores for the book method show a mean score of 59.1 and for retention-progress 34.3; the superiority of the lecture method over the book method, 2.7, with a true difference of 1.7, which leads to a probability that the lecture method excels the book method in more than 87 cases out of a 100.

The data of Table XXII on the retention-progress of pupils as shown by one of the several methods rather than another, indicate that the amounts of retention-progress in the first unit of physics for the lecture and book methods were approximately equal and that each was noticeably less than the retention-

progress of the other two. The superiority of the demonstration method over the other two is statistically certain.

In employing the retention scores for comparison of methods the amount of content retained for the lecture and book methods is approximately equal. Here, as in retention-progress, the demonstration method is definitely superior to the lecture and book methods.

The order of rank of method with regard to retention and retention-progress is as follows: Demonstration method would receive first place and the book method assumes third place.

TABLE XXIII

Showing the comparison of lecture, demonstration and book method for the First Unit of Physics by the percentile, final and progress scores.

Comparison of methods in terms of percentile, final and progress scores.											
		Final					Progress				
Meth.	N	Med.	P10	P90	P25	P75	Med.	P10	P90	P25	P75
B	59	53.8	36.9	71.8	45.4	62.4	30.3	8.1	46.3	21.1	40.8
L	174	60.6	39.4	81.9	45.6	71.0	40.1	14.0	61.8	26.6	49.1
D	151	66.0	50.5	81.8	59.6	75.4	46.8	27.6	64.4	40.3	60.2

In consideration of the percentile progress scores for comparison of methods we find the demonstration method obviously superior to the other two methods throughout and the lecture method superior to the book method throughout. This no doubt was due to the character of the unit since it involved an interpretation of the intensity of light and the laws of reflection and refraction.

When the percentile final scores are employed for comparison of methods the differences between the three methods are not as great as in the percentile progress scores although the order of rank of method remains the same for both, viz: Demonstration method first and book method third.

TABLE XXIV

Showing the comparison of lecture, demonstration and book methods for the First Unit of Physics by the percentile, retention and retention-progress scores.

Comparison of methods in terms of percentile, retention and retention-progress scores.											
		Retention					Retention-Progress				
Meth.	N	Med.	P10	P90	P25	P75	Med.	P10	P90	P25	P75
B	59	60.3	34.9	86.8	46.3	70.9	36.9	7.3	57.1	23.2	46.3
L	174	59.0	35.3	80.4	45.5	65.9	39.4	13.4	62.7	23.5	49.8
D	151	67.2	46.8	82.3	60.3	76.3	48.2	27.1	65.6	39.8	60.7

For all percentiles in retention-progress the demonstration method is noticeably superior to the other two. For the lower quartile the lecture and book methods are approximately equal in value, and in the upper 75 and 90 per cents the lecture method excels the book method.

For the 25, 50, 75 and 90 per cents in the retention scores the book method is superior to the lecture method and in all percentiles the demonstration method is superior to the other two.

In the first unit of physics, and with regard to retention scores the order of rank of methods is demonstration method first and lecture method third. In the retention-progress scores the demonstration would receive first place and the book method third.

Comparison of methods used in the second unit of physics: The comparison of progress scores for the book, lecture, and demonstration methods, as applied in the second unit of physics, is made through the use of the data on measures of initial, final and progress scores presented in Table XXV.

TABLE XXV

Showing the comparison of methods in the Second Unit of Physics as to mean progress achieved.

		Final	Progress		Contrast	
Meth.	N	M	M PE$_M$	Diff. of Means	Diff. / PE$_D$	Prob. D>0
B	147	56.0	27.8±0.8	L-B 9.2	7.7	99 in 100
L	165	66.8	37.0±0.9	L-D 1.4	0.8	69 in 100
D	90	74.0	35.6±1.6	D-B 7.8	4.3	99 in 100

The table should be read as follows: The 147 cases of final scores for the book method show a mean score of 56.0 and of progress scores a mean score of 27.8; the superiority of the lecture method over the book method, 9.2, with a true difference of 7.7 which leads to a probability that the lecture method excels the book method in more than 99 cases out of a 100.

The data of Table XXV on the progress of pupils as shown by one of the several methods rather than another, indicate that the amounts of progress in the second unit of physics for the demonstration and lecture methods were approximately equal and that each was noticeably greater than the progress for the book method. Statistical certainty is to be attached to the superiority of the lecture and demonstration methods over the book method, whereas much less significance should be attached to the superiority of the lecture over the demonstration method.

When the final scores are employed instead of the progress

scores as the basis for comparing the methods, the demonstration method is noticeably superior to the lecture method, while the book method is very much inferior to the two former.

Thus it is seen that the progress scores would give first place to the lecture method, whereas a consideration of the final scores would place the demonstration definitely in the lead. The book method assumes third place on both bases.

Comparison of methods used in the second unit of physics: The comparison of retention-progress scores for the book, lecture, and demonstration methods, as applied in the second unit of physics, is made through the use of data on measures of initial, retention and retention-progress scores presented in Table XXVI.

TABLE XXVI

Showing the comparison of methods in the Second Unit of Physics as to mean progress achieved.

		Retention	Retention-Progress		Contrast		
Meth.	N	M	M PE$_M$	Diff. of Mean PE	Diff. / PE$_D$		Prob. D>0
B	147	56.6	30.4±0.9	L-B 5.7	4.8		99 in 100
L	165	65.9	36.0±0.8	L-D 0.4	0.3		58 in 100
D	80	74.8	35.6±1.5	D-B 5.2	2.9		97 in 100

The table should be read as follows: The 147 cases of retention scores for the book method show a mean score of 56.6 and a retention-progress mean of 30.4; the superiority of the lecture method over the book method, 5.7, with a true difference of 4.8 which leads to a probability that the lecture method excels the book method in more than 99 cases out of a 100.

The data of Table XXVI on the retention-progress of pupils as shown by one of several methods rather than another, indicate the amounts of retention-progress in the second unit of physics for the lecture and demonstration methods were approximately equal and that each was noticeably greater than the book method. The superiority of the lecture and demonstration methods over the book method was statistically certain but much less significance may be attached to the superiority of the lecture over the demonstration method. When the retention scores are employed the superiority of the lecture and demonstration methods over the book method is very significant and the superiority of the demonstration method over the lecture method is equally certain.

The order of rank of method for the retention scores is: Demonstration first with book third, while in the retention-progress scores the order is: Lecture first and book third.

TABLE XXVII

Showing the comparison of lecture, demonstration and book methods for the Second Unit of Physics by the percentile, final and progress scores.

Comparison of methods in terms of percentile, final and progress scores.											
		Final					Progress				
Meth.	N	Med.	P10	P90	P25	P75	Med.	P10	P90	P25	P75
B	147	49.0	30.9	81.9	42.9	67.4	27.8	8.9	46.9	18.0	39.8
L	165	66.4	36.6	91.3	55.5	82.1	35.6	17.5	61.3	24.3	47.6
D	80	84.7	40.	95.6	65.0	87.5	40.8	7.5	62.5	20.8	49.2

For the 50, 75 and 90 per cents of the progress scores the demonstration method is obviously superior to the other two, whereas in the lower decile and quartile the lecture method is superior to the other two. Both the lecture and demonstration methods are superior to the book method.

For the lower decile the order of method: Lecture, book, demonstration.

For the upper decile it is: Demonstration, lecture, book.

When the percentile final scores are considered, the order of method is: Demonstration, lecture, and book for all percentile scores.

For the lower decile and quartile in the retention-progress scores the demonstration and book methods are approximately of equal value and both are obviously inferior to the lecture method. For the upper quartile and decile the demonstration and lecture methods are markedly superior to the book method and the demonstration method excels the lecture method. It may be said for the percentile retention-progress scores that the order of rank of methods for the upper level groups is: Demonstration, lecture, and book; whereas in the lower level groups it is: Lecture, book, and demonstration.

With regard to the percentile retention scores the order of rank of methods for the upper level groups is: Demonstration, lecture and book; in the lower level groups the order of rank of method is the same as for the upper.

TABLE XXVIII

Showing the comparison of lecture, demonstration and book methods for the Second Unit of Physics by the percentile, retention and retention-progress scores.

		Retention					Retention-progress				
Meth.	N	Med.	P10	P90	P25	P75	Med.	P10	P90	P25	P75
B	147	60.7	32.7	83.6	44.9	71.5	29.2	10.4	53.2	21.0	41.7
L	165	65.7	42.5	87.9	58.9	80.2	37.3	18.1	57.5	25.6	45.9
D	80	81.0	43.4	97.1	62.5	90.5	37.5	10.0	62.5	20.9	50.0

Comparison of methods used in the third unit of physics: The comparison of progress scores for the book, lecture and demonstration methods, as applied in the third unit of physics, is made through the use of data on measures of initial, final and progress scores presented in Table XXIX.

Table XXIX shows the progress of pupils in the third unit of physics for the lecture and demonstration methods to be approximately equal and both obviously inferior to the book method with statistical certainty. The order of rank of methods for the progress scores appears to be, book, lecture, and demonstration.

In considering the final scores there is little significance attached to the superiority of the demonstration method over the lecture method. However both are decidedly inferior to the book method with certainty. The rank of method for the final scores seems to be: Book, demonstration, and lecture.

Comparison of methods used in the third unit of physics: The comparison of retention-progress scores for the book, lecture, and demonstration methods, as applied in the third unit of physics, is made through the use of the data on measures of initial, retention, and retention-progress scores presented in the following table.

TABLE XXIX

Showing the comparison of methods in the Third Unit of Physics as to mean progress achieved.

		Final	Progress		Contrast	
Method	N	M	M PE_M	Diff. of Means	Diff. / PE_D	Prob. D>0
B	173	72.1	34.9±0.9	B-L 6.3	3.8	99 in 100
L	63	67.9	28.6±1.7	L-D 1.4	0.7	68 in 100
D	156	69.4	27.2±1.0	B-D 7.7	5.8	99 in 100

The table should be read as follows: The 173 cases of final scores for the book method show a mean score of 72.1 and of the progress scores a mean of 34.9; the superiority of the book method over the lecture method, 6.3, with a true difference of 3.8, which leads to a probability that the book method excels the lecture method in more than 99 cases out of a 100.

Table XXX shows the amount of progress made by pupils in the third unit of physics by the lecture and demonstration methods is approximately the same and that both methods are inferior to the book method. There is statistical significance attached to the superiority of the book method over the other two. The order of rank of method for the retention-progress scores seems to be: Book, lecture, and demonstration.

TABLE XXX

Showing the comparison of methods in the Third Unit of Physics as to mean retention-progress achieved.

Meth.	N	Retention M	Retention-Progress M	PE$_M$	Contrast Diff. of Means	Diff. / PE$_D$	Prob. D>0
B	173	66.0	28.9	±0.9	B-L 3.1	1.7	88 in 100
L	63	65.0	25.8	±1.6	L-D 0.2	0.1	53 in 100
D	156	67.8	25.6	±0.9	B-D 3.3	2.6	96 in 100

The table should be read as follows: The 173 cases of retention scores for the book method show a mean score of 66.0 and for retention-progress mean of 28.9; the superiority of the book method over the lecture method, 3.1, with a true difference of 1.7, which leads to the probability that the book method excels the lecture method in more than 88 out of 100.

In the retention scores the value of the book and lecture methods and the book and demonstration methods is about equal with a slight preference of the book over the lecture method and a slight preference of the demonstration method over the book method. Very little significance may be attached to the preference of the demonstration method over the lecture method. The order of rank of methods in the retention scores appears to be: Demonstration, book, and lecture, but with no significant comparison between the three methods.

For the fifty per cent in the percentile progress scores, the lecture and demonstration methods are approximately of equal value and for the lower quartile and upper decile the lecture and book methods are approximately of equal value. The superiority of book method over the other two in every percentile is very obvious.

For the lower groups the order of rank of methods appears to be, book, demonstration and lecture in P10 and P25, and for the upper groups, P75 and P90, the order is: Book, lecture, and demonstration. For the percentile final scores the order of rank of methods is: Book, demonstration and lecture in all per cents except the ninety per cent in which the honors are evenly divided between the lecture and demonstration methods for second place.

In consideration of the percentile retention-progress scores the book method is noticeably superior to the other two. Approximately equal value is assigned to the lecture and demonstration methods for the ten and fifty per cents and equal value to the lecture and book methods for the seventy-five and ninety

per cents. The order of rank of methods appears to be: Book, demonstration, and lecture for the lower groups; and book, lecture and demonstration for the higher groups.

In considering the percentile retention scores the order of rank for the higher groups is reversed and appears to be, demonstration, lecture, and book; and in the lower decile it is: book, demonstration, and lecture, while in the lower quartile the order gives the demonstration method first place and the book method second.

TABLE XXXI

Showing the comparison of lecture, demonstration and book methods for the Third Unit of Physics by the percentile, final and progress scores.

Comparison of methods in terms of percentile, final and progress scores.											
		Final					Progress				
Meth.	N	Med.	P10	P90	P25	P75	Med.	P10	P90	P25	P75
B	173	74.8	51.4	91.9	62.2	82.5	37.9	11.3	58.7	23.0	47.4
L	63	72.0	40.4	89.5	55.8	82.8	26.9	2.8	58.5	13.8	43.0
D	156	73.0	45.3	90.2	58.1	82.8	26.6	4.4	44.9	15.9	38.3

TABLE XXXII

Showing the comparison of lectures, demonstration and book methods for the Third Unit of Physics by the percentile, retention and retention-progress scores.

Comparison of methods in terms of percentile, retention and retention-progress scores.											
		Retention					Retention-Progress				
Meth.	N	Med.	P10	P90	P25	P75	Med.	P10	P90	P25	P75
B	173	61.2	44.7	85.7	57.6	79.0	29.1	4.1	52.9	18.8	42.5
L	63	68.8	41.9	86.2	51.3	80.6	24.7	2.7	52.8	9.8	41.8
D	156	69.6	43.0	87.9	58.0	81.6	24.5	3.4	44.9	15.5	37.1

Summary of the Findings of series two, physics, with regard to the results of teaching by three methods as indicated by preferential ranking: Table XXXIII shows the summary order of rank of methods in the three units of physics for all tests and progress scores derived from them. Tables XXIV, XXXV and XXXVI show the order of rank of methods by units for physics by percentile, initial, final, progress, retention and retention-progress scores.

Table XXXVII shows a composite order of rank of method for three units of physics and table XXXVIII shows a composite order of rank of methods by percentile, initial, final, progress, retention and retention-progress scores for the three units of physics.

TABLE XXXIII

Summary table showing the order of rank of method in the three units of physics for all test scores and their resulting progress scores.

Tests	Unit I	Unit II	Unit III
Initial	B-L-D	D-L-B	D-L-B
Final	D-L-B	D-L-B	B-D-L
Progress	D-L-B	L-D-B	B-L-D
Retention	D-B-L	D-L-B	D-B-L
Retention-Progress	D-L-B	L-D-B	B-L-D

TABLE XXXIV

Summary table showing the order of rank of method in the first unit of physics with regard to percentile scores in each test and the resulting progress scores.

Tests	Med.	P10	P25	P75	P90
Initial	B-L-D	B-L-D	B-L-D	B-L-D	B-L-D
Final	D-L-B	D-L-B	D-L-B	D-L-B	L-D-B
Progress	D-L-B	D-L-B	D-L-B	D-L-B	D-L-B
Retention	D-B-L	D-B-L	D-B-L	D-B-L	B-D-L
Retention-Progress	D-L-B	D-L-B	D-L-B	D-L-B	D-L-B

TABLE XXXV

Summary table showing the order of rank of method in the second unit of physics with regard to percentile scores in each test and the resulting progress scores.

Tests	Med.	P10	P25	P75	P90
Initial	D-L-B	D-L-B	D-L-B	D-L-B	D-L-B
Final	D-L-B	D-L-B	D-L-B	D-L-B	D-L-B
Progress	D-L-B	L-B-D	L-D-B	D-L-B	D-L-B
Retention	D-L-B	D-L-B	D-L-B	D-L-B	D-L-B
Retention-Progress	D-L-B	L-B-D	L-B-D	D-L-B	L-B-D

TABLE XXXVI

Summary table showing the order of rank of methods in the third unit of physics with regard to percentile scores in ech test and the resulting progress scores.

Tests	Med.	P10	P25	P75	P90
Initial	D-B-L	D-L-B	D-L-B	D-L-B	D-L-B
Final	B-D-L	B-D-L	B-D-L	D-L-B	B-D-L
Progress	B-L-D	B-D-L	D-B-L	B-L-D	B-L-D
Retention	D-L-B	B-D-L	D-B-L	D-L-B	D-L-B
Retention-Progress	B-L-D	B-L-D	B-D-L	B-L-D	B-L-D

Summary of Series Two, Physics.

Summary Table XXXIII shows the demonstration method ranking first in every test in the first unit, save the initial test in which it ranks last, and the significance of its position over the other two methods is substantiated with statistical certainty. Its superiority over the other two methods is obvious in all tests except in the initial test. The lecture method is superior to the book method with certainty in the final and progress tests, but in the retention-progress test the difference in favor of the lecture

method is significant only by a probability of 87 chances out of 100. The book method shows a very slight advantage over the lecture method in the retention test. It might be said with safety that the demonstration method, for the first unit of physics is superior to the other two methods and that the lecture method holds a distinct advantage over the book method except in the retention test. So far as progress is concerned, the order would be, demonstration, lecture and book methods.

The second unit of physics presents a somewhat different picture than the first. The lecture method has a significant advantage over the book method in all tests, and a slight advantage over the demonstration method in both the progress and retention-progress scores, the advantage being however, not significant. In the final and retention tests the demonstration method has the advantage over the lecture method with a margin of statistical certainty and distinct advantage over the book method in all the tests save the retention-progress where the probability is 97 chances out of 100 of being significant.

In the second unit of physics the median scores for all tests gave the demonstration method first place and lecture method second place in rank of methods. In the upper quartile the demonstration method ranks first with the lecture method second, and in the upper decile the demonstration method ranks first with the lecture method second, except in the retention-progress test scores where the lecture method ranks first and the book method second. As for the lower decile and quartile, in the final and retention tests, the demonstration method ranks first and the lecture method second, but in the progress and retention-progress scores, the lecture method ranks first with the book method second, except in the progress score of the lower quartile. We might conclude then as follows: In the progress tests for the lower groups, the demonstration method is superior.

The third unit of physics gives the book method first place for all level groups in the progress scores, including retention-progress and the lecture method second place in the median group and the two higher groups, while in the lower groups the demonstration method is superior to the lecture method and takes second place. In retention, the demonstration ranks first in all groups except the lowest.

The third unit of physics gives the book method the advantage over the demonstration method in the final scores with a margin

of safety of 93 chances out of 100 and in the progress scores with certainty. It retains its superiority in both the retention scores and retention-progress scores; in the former with a margin of safety equal to 84 chances out of 100 and in the latter 96 chances out of 100. The book method shows superiority over the lecture method in all tests but not with safety in the retention and retention-progress scores, the probability of safety being less than 90 out of 100 chances. In the progress and retention-progress scores the lecture method holds a slight advantage over the demonstration method, and the reverse is true in the final and retention scores except that the advantage in favor of the demonstration is greater.

We might conclude then that in the third unit of physics the book method holds the advantage with the honors evenly divided between the lecture and demonstration methods for second place. In the third unit one also finds that the lecture method has a distinct advantage over the demonstration method in the progress scores.

Consideration of the ranking of methods by percentile scores in the three units of physics.

It is very apparent that the demonstration method holds first place in the first unit of physics for all percentiles save in the upper decile in retention. The lecture method takes an easy second place except in the retention scores in the median, P 25 and P75, where the book method is second and P90 where the book method is first.

TABLE XXXVII

Showing the order of rank of methods for the three units of physics by frequency of rank in each test and progress scores derived from the tests.

Method	Final	Progress	Retention	Retention-Progress	Total Preference
D	2	1	3	1	7
L	0	1	0	1	2
B	1	1	0	1	3

Table XXXVII shows a consistent lack of preferential difference between methods in the progress and retention-progress scores ranking and a distinct preference for the demonstration method in the final and retention scores. With regard to the total preference in ranking of the three methods the demonstration method would easily take first place and the lecture method third.

TABLE XXXVIII

Showing the order of rank of methods by percentile final, progress, retention and retention-progress scores in the second series, physics.

Percentiles	Meth.	Final	Progress	Retention	Rentention-Progress	Total Preferred
P10	D	2	1	2	1	6
	L	0	1	0	1	2
	B	1	1	1	1	4
P25	D	2	2	3	1	8
	L	0	1	0	1	2
	B	1	0	0	1	2
Med.	D	2	2	3	2	9
	L	0	0	0	0	0
	B	1	1	0	1	3
P75	D	3	2	3	2	10
	L	0	0	0	0	0
	B	0	1	0	1	2
P90	D	1	2	1	1	6
	L	1	0	0	1	2
	B	1	1	1	1	4

Table XXXVIII shows a decided preference for the demonstration method in all the percentiles. In the 50 and 75 per cents the lecture method has no rank status at all, and in every percentile the lecture method ranks third. There is a marked consistency in the ranking of methods for the progress and retention-progress scores. In the extreme percentiles there is decidedly less preferential difference with regard to rank of methods for all tests and progress scores.

Comparison of Methods in the Three Units of Zoology.

Comparison of methods used in the first unit of zoology: The comparison of progress scores for the book, lecture, and demonstration methods, as applied in the first unit of zoology, is made through the use of the data on measures of initial, final, and progress scores presented in Table XXXIX.

In Table XXXIX the amounts of progress made by pupils in the first unit of zoology by the lecture and book methods is approximately of equal value showing a slight preference for the lecture method. The superiority of the lecture method over the demonstration method is more obvious and slightly more significant than over the book method. No significance may safely be attached to the superiority of the book method over the demonstration method. The order of rank of methods seems to be: Lecture, book, and demonstration.

TABLE XXXIX

Showing the comparison of methods in the First Unit of Zoology as to mean progress achieved.

Method	N	Final Progress M	M PE	Contrast Diff. of Means	Diff. / PE$_D$	Prob. D>0
B	183	70.1	46.8±0.8	L-B 1.3	1.1	78 in 100
L	152	70.6	48.1±0.9	L-D 3.5	2.7	97 in 100
D	95	73.4	44.6±1.0	B-D 2.2	1.8	88 in 100

The table should be read as follows: The 183 cases of final scores for the book method show a mean score of 70.1 and of the progress scores 46.8; the superiority of the lecture method over the book method, 1.3, with a true difference of 1.1, which leads to a probability that the lecture method excels the book method in more than 78 cases out of a 100.

In considering the final scores much less significance may be attached to the superiority of the lecture method over the book method than in the progress scores. The demonstration method, for the final scores, appears to be superior to the other two with statistical certainty which is quite the reverse of the findings in the progress scores. In the final scores then we find the order of rank of method to be: Demonstration, lecture, and book.

Comparison of methods used in the first unit of zoology: The comparison of progress scores for the book, lecture, and demonstration methods, as applied in the first unit of zoology, is made through the use of the data on measures of initial, retention, and retention-progress scores presented in the Table XL.

TABLE XL

Showing the comparison of methods in the First Unit of Zoology as to mean progress achieved.

Meth.	N	Mean Retention Scores M	Mean Retention-Progress Scores M PE	Contrast Diff. of Means	Diff. / PE$_D$	Prob. D>0
B	183	75.2	52.0±0.8	L-B 3.5	2.9	97 in 100
L	152	77.9	55.4±0.9	L-D 10.9	8.1	99 in 100
D	95	79.5	44.5±1.0	B-D 7.4	5.9	99 in 100

The table should be read as follows: The 183 cases of retention scores for the book method show a mean score of 75.2 and of retention-progress 52.0; the superiority of the lecture method over the book method, 3.5 with a true difference of 2.9, which leads to a probability that the lecture method excels the book method in 97 cases out of 100.

In considering the retention-progress scores, shown in Table XL, we find the same change as in the progress over the final

scores. While in the retention scores the demonstration was distinctly superior to the other two methods, in the retention-progress it is distinctly inferior. The lecture and book methods are both superior to the demonstration method with statistical certainty and the lecture method is superior to the book method with a safe margin. In summary of this unit for the final and retention tests and their respective progress scores, we may safely say that the demonstration method is superior to the other two methods in the final and retention tests, and the lecture method superior to the other two in their respective progress scores. In all measures the lecture method is superior to the book method with high significance in the retention and retention-progress scores, and only slightly in the final and progress scores. The book method, in both progress and retention-progress scores, is superior to the demonstration method.

TABLE XLI

Showing the comparison of lecture, demonstration and book methods for the First Unit of Zoology by the percentile, final and progress scores.

Comparison of methods in terms of percentile, final and progress scores.											
		Final					Progress				
Meth.	N	Med.	P10	P90	P25	P75	Med.	P10	P90	P25	P75
B	183	71.5	57.1	84.0	63.3	79.8	48.1	24.7	64.8	37.8	58.9
L	152	74.0	47.7	83.0	65.6	81.4	49.6	25.0	68.5	36.5	62.2
D	95	75.5	61.3	85.0	66.7	82.0	43.0	27.5	65.4	35.6	55.9

For the lower decile in the percentile progress scores the demonstration method excels the other two methods but for the lower quartile the book method excels the other two. For the upper decile and quartile the lecture method is superior to the other two and the book and demonstration methods appear to have approximately the same value.

For the percentile final scores the demonstration method is obviously superior to the other two and for the lower and upper deciles the book method is noticeably superior to the lecture method.

The order of rank of methods in both upper and lower groups seems to be changed due to the small differences between their percentile scores.

In consideration of the percentile retention-progress scores in Table XLII the three methods have approximately equal value in the lower decile and upper and lower quartiles, giving slight preference to the lecture method in the lower decile and to the book method in the upper quartile.

For the lower decile and quartile in the percentile retention scores the demonstration method is obviously superior to the other two methods. Approximately equal value is assigned to the three methods in the upper level groups with a slight preference for the lecture method.

TABLE XLII

Showing the comparison of lecture, demonstration and book methods for the First Unit of Zoology by the percentile, retention and retention-progress scores.

Comparison of methods in terms of percentile retention and retention-progress scores.											
		Retention					Retention-Progress				
Meth.	N	Med.	P10	P90	P25	P75	Med.	P10	P90	P25	P75
B	183	78.6	59.0	90.0	65.3	84.5	53.6	32.4	73.2	43.4	63.1
L	152	81.6	61.2	93.5	65.0	80.1	59.6	33.2	76.7	44.1	61.3
D	95	85.6	65.9	91.3	73.9	85.5	50.9	31.1	68.4	41.2	63.0

Comparison of methods used in the second unit of zoology: The comparison of progress scores for the book, lecture, and demonstration methods, as applied in the second unit of zoology, is made through the use of the data on measures of initial, final and progress scores presented in Table XLV.

TABLE XLIII

Showing the comparison of methods in the Second Unit of Zoology as a mean progress achieved.

		Final	Progress		Contrast		
Method	N	M	M_P	PE_M	Diff. of Means	Diff. / PE_D	Prob. D>0
B	150	81.2	44.3±0.9		B-L 5.6	3.6	99 in 100
L	100	72.2	38.7±1.2		D-L 4.1	3.9	100 in 100
D	193	76.5	34.6±0.9		B-D 9.7	7.5	99 in 100

The table should be read as follows: The 150 cases of final scores for the book method show a mean score of 81.2 and of the progress scores 44.3; the superiority of the book method over the lecture method, 5.6, with a true difference of 3.6, which leads to a probability that the book method excels the lecture method in more than 99 cases out of a 100.

In consideration of the mean progress scores in the second unit of zoology statistical certainty is attached to the superiority of the book over the lecture and demonstration methods and of the demonstration over the lecture method. The order of rank of method is unmistakably book, demonstration, and lecture.

In consideration of the mean final scores in the second unit of zoology identical results are found to those of the mean progress scores. The order of rank of methods being: Book, demonstration, and lecture.

Comparison of methods used in the second unit of zoology: The comparison of progress scores for the book, lecture, and demonstration methods, as applied in the second unit of zoology, is made through the use of the data on measures of initial, retention and retention-progress scores presented in Table XLIV.

TABLE XLIV

Showing the comparison of methods in the Second Unit of Zoology as a mean progress achieved.

		Retention	Retention-Progress	Contrast		
Meth.	N	M_F	M_P PE$_M$	Diff. of Means	Diff. / PE$_D$	Prob. D>0
B	150	78.6	41.8±0.9	B-L 5.7	3.9	99 in 100
L	100	79.6	36.1±1.1	L-D 4.3	3.1	98 in 100
D	193	73.7	31.8±0.9	B-D 10.0	8.3	99 in 100

The table should be read as follows: The 150 cases of retention scores for the book method show a mean score of 78.6 and of the retention-progress 41.8; the superiority of the book method over the lecture method, 5.7, with a true difference of 3.9, which leads to a probability that the book method excels the lecture method in more than 99 cases out of a 100.

For the percentile progress scores the book method is noticeably superior to the other two in all percentile scores, and the demonstration method is obviously superior to the lecture method in all percentile scores.

TABLE XLV

Showing the comparison of lecture, demonstration and book methods for the Second Unit of Zoology by the percentile, final and progress scores.

Meth.	N	Med.	P10	P90	P25	P75	Med.	P10	P90	P25	P75
B	150	82.1	68.3	94.6	79.3	89.7	44.0	20.8	64.0	35.3	57.6
L	100	74.5	55.3	88.3	63.2	82.0	30.4	6.3	55.0	16.4	39.0
D	193	79.6	52.4	95.9	69.3	88.1	35.9	11.5	58.9	18.9	51.3

In the percentile final scores, and for the upper level groups, there is approximately equal value assigned to the demonstration and book methods. The book method is superior to the other two in the lower level groups and the lecture method is inferior to the demonstration method in all per cents except the ten percentile.

In consideration of the percentile retention-progress scores the book method is superior to the other two methods in every percentile score recorded, and the lecture method is superior to the demonstration method in every percentile score.

For the ninety per cent the value assigned to the book and lecture methods are approximately equal. The percentile retention scores show a different picture for the upper level groups. Here

the lecture method is superior to the other two methods. In all percentiles the book method excels the demonstration method.

In retention-progress scores, as shown in Table XLVI, the book method is superior to the two other methods, the lecture method ranks second and the book method third. In the retention scores the lecture method ranks first, the book method second and the demonstration method third.

The difference between the mean scores of the lecture and book methods are not significant in the retention scores, but statistical significant in the retention-progress scores and in favor of the book method. The difference between the mean scores of the book and demonstration methods for both the retention and retention-progress scores is significant and in favor of the book method.

TABLE XLVI

Showing the comparison of lecture, demonstration and book methods for the Second Unit of Zoology by the percentile retention and retention-progress scores.

Comparison of methods in terms of percentile retention and retention-progress scores.											
Meth.	N	Med.	P10	P90	P25	P75	Med.	P10	P90	P25	P75
B	150	78.6	67.2	91.7	75.4	85.6	41.4	21.7	61.0	34.4	53.9
L	100	80.6	62.0	96.0	75.0	93.3	36.3	16.1	60.0	25.5	48.0
D	193	77.0	52.3	91.2	65.7	83.8	32.5	11.5	56.0	1.84	44.9

The order of rank of methods in the percentile retention scores appears to be: Lecture, book, and demonstration for the upper level groups and book, lecture, and demonstration for the lower level groups.

Comparison of methods used in the third unit of zoology: The comparison of progress scores for the book, lecture, and demonstration methods, as applied in the third unit of zoology, is made through the use of the data on measures of initial, final, and progress scores presented in Table XLVII.

Table XLVII shows a significant preference of the lecture method over the book method and of the demonstration method over the other two methods.

In the percentile final scores the superiority of the demonstration method over the book method is definitely significant and the lecture method excels the book method with statistical certainty. The superiority of the demonstration method over the lecture method is less significant.

TABLE XLVII

Showing the comparison of methods in the Third Unit of Zoology as to mean progress achieved.

Meth.	N	Final	Progress	Contrast		
		M_F	M_P PE_M	Diff. of Means	Diff. / PE_D	Prob. D>0
B	102	67.1	32.5±1.3	L-B 6.9	4.3	99 in 100
L	185	70.9	39.4±0.9	D-L 7.2	4.8	99 in 100
D	144	71.4	46.6±1.2	D-B 14.1	10.9	99 in 100

The table should be read as follows: The 102 cases of final scores for the book method show a mean score of 67.1 and of the progress scores 32.5; the superiority of the lecture method over the book method, 6.9, with a true difference of 4.3, which leads to a probability that the lecture method excels the book method in more than 99 cases out of a 100.

Comparison of methods used in the third unit of zoology: The comparison of progress scores for the book, lecture, and demonstration methods, as applied in the third unit of zology, is made through the use of the data on measures of initial, retention and retention-progress scores presented in Table XLVIII.

TABLE XLVIII

Showing the comparison of methods in the Third Unit of Zoology as to mean progress achieved.

Meth.	N	Retention	Retention-Progress	Contrast		
		M_F	M_P PE_M	Diff. of Means	Diff. / PE_D	Prob. D>0
B	102	70.4	35.8±1.4	B-L 0.3	0.2	55 in 100
L	185	67.0	35.5±1.1	D-L 11.1	7.7	99 in 100
D	144	71.8	46.6±1.0	D-B 10.8	6.1	99 in 100

The table should be read as follows: The 102 cases of retention scores for the book method show a mean score of 70.4 and of retention-progress 35.8; the superiority of the book method over the lecture method, 0.3, with a true difference of 0.2, which leads to the probability that the book method excels the lecture method in more than 55 cases out of a 100.

Table XLVIII shows the superiority of the book over the lecture method to be very slightly significant but shows that the demonstration method is superior to the other methods with statistical certainty.

The order of rank of method for the mean retention-progress scores is; demonstration, book, and lecture. When the mean retention scores are considered the superiority of the demonstration method over the book method is not significant, and of the book method over the lecture method very slightly significant. Statistical certainty, however, may be attached to the difference

between the demonstration and lecture methods in favor of the former.

TABLE XLIX

Showing the comparison of lecture, demonstration and book methods for the Third Unit of Zoology by the percentile, final and progress scores.

Comparison of methods in terms of percentile, final and progress scores											
		Final					Progress				
Meth.	N	Med.	P10	P90	P25	P75	Med.	P10	P90	P25	P75
B	102	71.9	41.0	90.6	54.1	79.9	32.2	8.2	59.3	19.2	44.7
L	185	74.5	51.2	92.5	59.7	82.6	38.8	16.5	64.5	28.2	53.6
D	144	75.6	47.0	94.1	56.5	87.7	47.8	17.8	73.7	34.6	60.0

For all the percentiles in the progress scores the demonstration method is obviously superior to the other two methods. The lecture method is likewise superior to the book method in every percentile. Thus the order of rank of methods in the percentile progress scores is: Demonstration, lecture and book.

Considering the percentile final scores for the lower level groups the lecture method is superior to the other two, and for the upper level groups the demonstration method is superior to the other two methods.

In the percentile retention-progress scores the demonstration method is superior to the other two methods for every percentile and the lecture method excels the book method in the upper quartile. Approximately equal value is assigned to the lecture and book methods for the 90, 50, 25, and 10 per cents.

In considering the percentile retention scores the book method assumes superiority over the other two methods in the upper level groups and the demonstration method excels in the lower level groups.

TABLE L

Showing the comparison of lecture, demonstration and book methods for the Third Unit of Zoology by the percentile retention and retention-progress scores.

Comparison of methods in terms of percentile retention and retention-progress scores.											
		Retention					Retention-Progress				
Meth.	N	Med.	P10	P90	P25	P75	Med.	P10	P90	P25	P75
B	102	70.0	40.5	98.4	56.3	90.8	36.1	9.0	63.5	21.9	49.6
L	185	70.3	41.0	92.2	51.2	82.6	36.9	10.4	62.1	20.1	52.6
D	144	76.5	46.5	92.5	60.7	85.8	48.6	23.5	72.2	36.3	58.2

Summary of the findings of series three, zoology, with regard to the result of teaching by three methods as indicated by preferential

ranking. Table LI shows the order of rank of the three units of zoology for all test scores and the progress scores derived from them.

Tables LII, LIII and LIV show the order of rank of methods by percentile, final, progress, retention and retention-progress scores for the three units of zoology.

TABLE LI

Summary table showing the order of rank of method in the three units of zoology for all test scores and their resulting progress scores.

Tests	Unit I	Unit II	Unit III
Initial	D-B-L	L-D-B	B-L-D
Final	D-L-B	B-D-L	D-L-B
Progress	L-B-D	B-D-L	D-L-B
Retention	D-L-B	L-B-D	D-B-L
Retention-Progress	L-B-D	B-L-D	D-B-L

TABLE LII

Summary table showing the order of rank of method in the first unit of zoology with regard to percentile scores in each test and the resulting progress scores.

Tests	Med.	P10	P25	P75	P90
Initial	D-B-L	D-B-L	D-B-L	D-L-B	D-L-B
Final	D-L-B	D-B-L	D-L-B	D-L-B	D-B-L
Progress	B-L-D	D-L-B	B-L-D	L-B-D	L-D-B
Retention	D-L-B	D-L-B	D-B-L	D-B-L	L-D-B
Retention-Progress	L-B-D	L-B-D	L-B-D	B-D-L	L-B-D

TABLE LIII

Summary table showing the order of rank of method in the second unit of zoology with regard to percentile scores in each test and the resulting progress scores.

Tests	Med.	P10	P25	P75	P90
Initial	L-D-B	L-D-B	L-D-B	L-D-B	L-D-B
Final	B-D-L	B-L-D	D-B-L	B-D-L	B-D-L
Progress	B-D-L	B-D-L	B-D-L	B-D-L	B-D-L
Retention	L-B-D	B-L-D	L-B-D	B-L-D	L-B-D
Retention-Progress	B-L-D	B-L-D	B-L-D	B-L-D	B-L-D

TABLE LIV

Summary table showing the order of rank of methods in the Third Unit of Zoology with regard to percentile scores in each and the resulting progress scores.

Tests	Med.	P10	P90	P25	P75
Initial	B-L-D	B-L-D	B-L-D	B-L-D	B-L-D
Final	D-L-B	L-D-B	D-L-B	L-D-B	D-L-B
Progress	D-L-B	D-L-B	D-L-B	D-L-B	D-L-B
Retention	D-L-B	D-L-B	B-D-L	D-B-L	B-D-L
Retention-Progress	D-L-B	D-L-B	D-L-B	D-L-B	D-L-B

Summary Table LI shows the order of rank of methods in each of three units of zoology for all test scores and their resulting

progress scores. Considering all three units and all measures used the demonstration method is superior to the other two methods. It is especially apparent in the third unit of this series, while in the second unit the book method holds first rank in the final and both progress scores. The lecture method is superior to the other two methods in the progress and retention-progress scores of the first unit but the demonstration method is superior to the lecture method in this unit in the final and retention scores. In the three units the lecture and book methods divide honors for second place and the three methods divide honors evenly for third place. So far as progress and retention-progress scores are concerned in the three units, the lecture method is first and the demonstration method last in the first unit; the book method is first in the second unit and the demonstration method is first in the third unit.

In considering the median and percentile scores for comparison of methods in unit one of this series, we find for the median and percentile scores of the final and retention tests the demonstration method superior except in the upper decile of the retention test, in which the lecture method is superior. In considering the progress and retention-progress scores the lecture method is superior, for the upper level groups in the progress scores and the lower level groups in the retention-progress scores, and the 90th percentile scores, while the book method is superior in the upper quartile.

In unit two of this series, the book method is superior in the final, progress and retention-progress scores except in the 90th percentile of the final scores, and the demonstration method is second in the progress scores and third in the retention-progress scores.

In the third unit shown in summary table LIV, we find the demonstration method first in the progress and retention-progress scores, the lecture method second and the book method last, but in the final and retention scores, the order is changed. Here the demonstration method is first in the median and upper quartile and decile for the final scores and first in the median and lower quartile and decile in the retention scores, while the book method is first in the retention scores in the upper decile and quartile, and in the final scores the lecture method is superior in the lower decile and quartile scores.

Table LV shows by summary, the order of rank of methods in the third series, zoology. Table LVI shows by summary the

order of rank of methods by percentile test and progress scores, in the third series, zoology. This table gives also a preferential total summary for consideration of choice of methods in all three units and for all test and progress scores.

TABLE LV

Showing the order of rank of methods for the Three Units of Zoology by frequency of rank in all tests and progress scores derived from them.

Method	Final	Progress	Retention	Retention-Progress	Total Preference
D	2	1	2	1	6
L	0	1	1	1	3
B	1	1	0	1	3

Table LV shows a consistent lack of preference for any method in the progress and retention-progress scores of the three units of zoology. With reference to the total preference for all tests and progress scores the demonstration method is obviously first, with equal rank assigned to the other two methods.

TABLE LVI

Showing the order of rank of methods by percentile final, progress, retention and retention-progress scores in the Third Series, Zoology.

Percentile	Meth.	Final	Progress	Retention	Retention-Progress	Total Preference
P10	D	1	2	2	1	6
	L	1	0	0	1	2
	B	1	1	1	1	4
P25	D	1	1	2	1	5
	L	1	0	0	1	2
	B	1	2	1	1	5
Med.	D	2	1	2	1	6
	L	0	0	1	1	2
	B	1	2	0	1	4
P75	D	2	1	1	1	5
	L	0	1	1	0	2
	B	1	1	1	2	5
P90	D	3	1	0	1	5
	L	0	1	2	1	4
	B	0	1	1	1	3

In consideration of the ranking of methods by percentile scores in the third series, zoology, the demonstration method received first place in the extreme percentiles, P10 and P90 and also P50. Equal value seems to be assigned to the demonstration and book methods in P25 and P75. Here again as in physics, the lecture method assumes third place.

There appears to be no preferential difference in methods in the final and retention-progress scores for P10, P25, and P90 in the third series, zoology. This table gives also a preferential total summary for consideration of choice of methods in all three units and for all test and progress scores.

Summary of the findings in the three series, botany, physics and zoology. Table LVII shows the order of rank of methods by the frequency of rank in the tests and progress scores for each series and the total preferential frequency for all series.

Table LVIII shows the order of rank of methods by the frequency of rank in the percentile final, progress, retention, and retention-progress scores for the three series and the frequency of total preference for all series.

TABLE LVII

Showing the order of rank of methods for each series, botany, physics and zoology, in all tests and progress scores derived from them by frequency of rank and total frequency for all series.

Method	Final	Progress	Retention	Retention Progress	Total Preference
Series I—Botany					
D	0	2	1	2	5
L	2	1	1	1	5
B	1	0	1	0	2
Series II—Physics					
D	2	1	3	1	7
L	0	1	0	1	2
B	1	1	0	1	3
Series III—Zoology					
D	2	1	2	1	6
L	0	1	1	1	3
B	1	1	0	1	3
Total for Three Series					
D	4	4	6	4	18
L	2	3	2	3	10
B	3	2	1	2	8

Table LVII gives equal choice to the demonstration and lecture methods in botany as shown by the total preference frequency. In both physics and zoology the demonstration method receives first place, whereas the lecture method assumed third place in physics and shares honors with the book method in zoology for second place.

In physics and zoology the demonstration method receives preference over the other methods in the final and retention scores and in botany in the progress and retention-progress scores. There is marked consistency between the order of rank of methods in the progress and retention-progress scores and none whatever between the final and retention scores.

For the progress and retention-progress scores in physics and zoology, the order of rank of methods shows no preference as to method.

It appears that for immediate and delayed recall of botany content, the demonstration method is more effective and the book method of no effect. The final and retention test results in physics and zoology indicate an unmistakable preference for the demonstration method.

The total frequency of all preferences for the three series merits consideration on the grounds that frequency of rank of methods in three types of content and for all types of tests, necessarily points to a method preference in all situations, and presents a total of frequency of preference of one of several methods in total situations.

The demonstration method ranks first for all series and in all test situations. The book method ranks second in the final scores and assumes third place in all the rest of the scores.

Table LVIII shows, by the total preference frequency, that the order of rank of methods in all the percentiles gives the demonstration method first place. In the extreme percentiles, viz. P10 and P90, the book method assumes second place, and in the lower quartile divides honors with the lecture method.

There is such a close relationship between the rank of the lecture and book methods, about the median, that they invariably reverse the order of rank in the retention-progress scores from that in the progress scores.

So far as progress in the three types of content is concerned, there is no choice for second place, between the lecture and book methods in the higher level groups. In the retention-progress scores, and for the three types of content, the lecture method holds second place for the lower groups and the book method for the higher level groups. The former groups appear to remember better what was taught than what they read. This fact is borne out in a measure in the questionnaire which follows, in which pupils have expressed a preference for the lecture meth-

TABLE LVIII

Showing the order of rank of methods by frequency of rank in the three series, botany, physics, and zoology in the percentile scores for all tests and progress scores.

Total for Botany, Physics and Zoology						
Percentiles	Meth.	Final	Progress	Retention	Reten. Pro.	Total Preference
P10	D	4	4	5	4	17
	L	3	1	1	3	8
	B	2	4	3	2	11
P25	D	3	4	7	4	18
	L	3	2	1	3	9
	B	3	3	1	2	9
Med.	D	5	4	7	4	20
	L	2	2	2	3	9
	B	2	3	0	2	7
P75	D	5	5	5	4	19
	L	2	2	3	2	9
	B	2	2	1	3	8
P90	D	6	5	2	4	17
	L	1	2	4	2	9
	B	2	2	3	3	10

od on those grounds. The higher level groups appear to remember more of what they read than of what they hear.

Comparison of Methods by Use of Questionnaire.

Questionnaire to Pupils Participating in the Study of Methods.

At the close of the investigation, a questionnaire was given to the pupils participating in the investigation to determine their reaction to the subject matter selected. Form II is a copy of the questionnaire recorded in the subsequent tables. The main object of this questionnaire was to show possible relationship between their choice of subject matter and methods, and the results obtained from the study of subject matter by each method.

Table LIX shows the responses to question 1 of the questionnaire for boys and girls according to the rank of subject matter. The girls ranked the study of animals as their first choice and the boys as their second choice. The boys ranked electricity as their first choice and the girls ranked plants as their second choice. Both boys and girls ranked light as their third choice. Taking the groups as a whole, animals ranked first, with electricity a close second to animals; plants ranked second and light third.

The subject of plants came in the first series under botany and animals and third series under zoology while the subject of light came in the second series under the subject of physics.

FORM II

Questionnaire to Pupils Taking General Science.

School.....Age.....Sex.....Date.....

Do not sign your name. Be frank in your answers. Read each statement first, then think how you should answer before writing.

1. During this semester you have been studying about the following subjects:
   A. Plants B. Animals C. Light
   D. Electricity
   Place a 1 before the subject you liked the best; place a 2 before the subject you liked second best; place a 3 before the subject you liked third best.
2. Give three good reasons why you selected the subject in the first question as your first choice.
   a.....
   b.....
   c.....
3. You were taught each of these subjects by three methods:
   a. Text Book.
   b. Lecture.
   c. Telling-Demonstration.
   Place a 1 before the method by which you learned the most about the subject; place a 2 before the method by which you succeeded next best in the subject.

TABLE LIX

Showing rank of subjects selected for the study by boys and girls.

Subjects		Rank 1	2	3	Total
Plants	Boys	19	60	59	138
	Girls	66	104	17	187
	Total	85	164	76	
Animals	Boys	81	81	70	232
	Girls	114	60	16	190
	Total	195	141	86	
Light	Boys	9	77	80	166
	Girls	16	15	121	142
	Total	25	92	201	
Electricity	Boys	147	42	43	232
	Girls	14	13	20	47
	Total	161	55	63	

Table should be read as follows: 19 boys and 66 girls ranked plants first; 60 boys and 104 girls ranked plants as their second choice; 147 boys and 14 girls ranked electricity as their first choice.

4. Now give two reasons why you liked the method of your first choice best of all.
   a.....
   b.....
5. Of the subjects you are taking this semester would you consider General Science: The most helpful; less helpful; the least helpful, of all the subjects? *Underline One.*
6. Would you recommend General Science to your friend and classmate as a subject worth taking?
7. Which one of the three methods did you like the least? Give your reasons in a few words:

Since the mean age of the boys was 15.2 years and that of the girls 15.2, it is quite certain that the factor of maturity was not responsible for the character of response according to sex, but rather due to interest in the subject matter.

It might also be noted that the range in age of the girls was 7 years and the boys 8 years. The girls varied in age from 11 to 18, only one girl being 11 years old, and five were 18 years old, while the boys ranged in age from 13 to 21 years, one being 21 years old and 11 thirteen years old. 37 percent of the boys were 15 years old while 45 percent of the girls were fifteen years old. 246 boys and 200 girls responded to the questionnaire.

Table LX shows the response of the pupils to question 3 of the questionnaire.

TABLE LX

3. You were taught each of these subjects by three methods:
   a. Text Book.
   b. Lecture.
   c. Telling-Demonstration.

   Place a 1 before the method by which you learned the most about the subject; place a 2 before the method by which you succeeded next best in the subject.

Method		Rank 1	2	3
Textbook	Boys	50	65	141
	Girls	31	50	107
	Total	81	115	248
Lecture	Boys	90	116	69
	Girls	82	66	42
	Total	172	182	112
Demonstration	Boys	138	73	42
	Girls	77	79	40
	Total	215	152	82

The responses of the girls to question 3, relative to methods, show a preference in favor of the lecture method for both first and second place. The boys indicate clearly their preference for

the demonstration method and the lecture method second. Taking the combined groups the rank is in favor of the demonstration method with the lecture method second and the book method third. Forty-nine percent of the boys ranked the demonstration first while only 42 percent of the girls ranked the lecture method first, dividing their preference quite evenly between the lecture and demonstration methods.

In summarizing the results of this table, we find that the demonstration method received 215 votes, the lecture method 172 and the book method 81 votes for first place or rank. The lecture method ranks second and the book method third.

Table LXI shows the response to question 5 in the questionnaire with regard to the query whether the subject of General Science was most helpful, less helpful or least helpful of the subjects taken during the semester.

TABLE LXI

Showing responses to question 5 in the questionnaire, which reads as follows:
5. Of the subjects you are taking this semester would you consider General Science: The most helpful; less helpful; the least helpful, of all the subjects? *Underline One.*

	Most Helpful	%	Less Helpful	%	Least Helpful	%
Boys	122	51.0	111	46.4	6	2.6
Girls	83	46.9	82	46.3	12	6.8
Total	205	49.27	193	47.36	18	3.37

According to the results of the responses to question 5 the course in General Science was most helpful to more than half of the boys and nearly half of the girls, and most helpful to almost half of the combined groups.

The responses to question 6, "Would you recommend General Science to your friend and classmate as a subject worth taking?" were over 98 percent "Yes." The responses to question 7, "Which one of the three methods did you like the least?" were varied and frequently inconsistent with the response to question 3. Whether this was due to error or carelessness cannot be determined but the results of the responses show definitely and with safety that the demonstration method is superior, the lecture method second and the book method last in rank of merit from the pupils' viewpoint. Table LXII shows the response to question 7. 56 percent of the girls scored the book method as the least valuable and 59 percent of the boys did the same. 57 per-

cent of the combined groups scored the book method as the least valuable and 24 percent of the pupils scored the lecture method as the least valuable. The demonstration seems to remain consistently the choice of the pupils.

TABLE LXII

Showing the response of the pupils to question 7 in the questionnaire, which reads: "Which one of the three methods did you like the least?"

	Lecture	Book	Demonstration
Girls	49	107—56%	36
Boys	57	141—59%	42
Total	106	248—57%	78

Some of the reasons given for liking the underlined method the least might be in order here. Reasons for not liking the method will be given for boys and girls for each method.

Textbook Method.

Girl 17: "Because I didn't get any thought out of it, the lecture is much better because it is more interesting."

Girl 15: "I don't care for the textbook method as it is not as interesting as the lecture, I can't get much out of it."

Girl 15: "I like the textbook the least because you don't have class discussions and you don't know what the others have to say."

Girl 14: "I liked the book method least because I can never get anything out of reading and it is not interesting to read any scientific things."

Girl 16: "Textbook method doesn't give things clear on some subjects. If you don't like science it makes it hard to understand."

Girl 17: "Because you can read ever so many words for the longest time without someone to explain the meaning and never understand what you are reading."

Girl 13: "Because in the book the subject was not explained as well as it was explained by a person."

Girl 13: "When you are to read, why, sometimes you do other things instead."

Boy 13: "Because the book does not explain it as good as the teacher."

Boy 14: "Because I cannot read an assignment over and get as much information out of it as I can by hearing others asking and answering questions in class."

Boy 14: "It is hard to pick out all of the necessary points."

Boy 15: "It was very dry and monotonous studying in the book."

Boy 16: "I could not concentrate easily because I would read on farther than I should."

Boy 17: "It is the least interesting to me. You do not get all the point like you do in Telling-Demonstration."

Boy 18: "No interest, too hard to understand."

Boy 19: "There was more to study and I got lower grades."

Lecture Method:

Boy 13: "Because the lecturer tells it in his own words which makes it hard to understand."

Boy 13: "Sometimes the notes cannot be gotten or the teacher does not make a point clear."

Boy 14: "It don't give anybody else a chance to talk."

Boy 15: "I liked the lecture the least because it seems to give me a *one man* impression of subjects and not an open discussion of everybody's opinion.'

Boy 16: "Get tired of listening to the teacher talk."

Boy 17: "Because I couldn't understand all the words that was said besides I would think that there wasn't any work for me to do."
Boy 18: "Lectures do not interest me therefore I do not gain much by listening. I like to read for myself and learn that way."
Boy 21: "The teacher talks to much and no one else has a chance."
Girl 14: "I did not understand the lesson when the lecture method was used. I did not like to take notes."
Girl 15: "When I read a book I can get my mind on what I'm trying to read, when we talk about science I lost interest."
Girl 16: "I don't like to take notes. Lecture is too monotonous."
Girl 17: "I didn't get much out of it and sometimes it would be hard to understand."
Girl 18: "Many times you cannot understand what the person is talking about. Sometimes it is hard to hear the one lecturing."

Demonstration Method:
Boy 21: "It is too slow and too many ways to get off the track."
Boy 18: "Simply because when a boy or girl gets up to tell something about the lesson and have not studied it you cannot get anything out of what they say."
Girl 18: "I could not remember the things as well as by other methods."
Girl 17: "It was easier for the mind to wander in this method. The facts were not brought out clearly as in the other methods."
Boy 17: "Because I get less out of it."
Girl 16: "Some classmates answer wrong and sometimes that answer stays in your head."
Boy 16: "Everybody is trying to talk at once and no one knows what they are talking about."
Girl 16: "Each one would have a different idea and then they would get into a quarrel about it, and besides it was harder to get."
Boy 15: "I don't like telling-demonstration because you don't get much time to take notes."
Boy 14: "Because one guy would get up and say the wrong thing and one guy would say it partly right and they get you all mixed up."
Girl 14: "There are inside materials that you cannot get and see and you have to use your imagination and half of the time it does not work."
Boy 13: "Because I don't understand the telling demonstration method as well as other methods."

There were many other responses and many pleaded lack of interest; lack of clearness; hard to understand; too much teacher talking; no chance for discussion; a few pupils do all the talking, etc., etc.

The responses to question 2 were not satisfactory for consideration since they were too indefinite. Most of them read like this: "I like animals," or "I like plants," or "They are more interesting," etc. Question 2 reads as follows:

> Give three good reasons why you selected the subject in the first question as your first choice.
> a.....
> b.....
> c. .....

Taking the group as a whole the demonstration method has a distinct advantage over the other two methods from the standpoint of pupil preference, and the lecture method second choice. As for the type of content, the third series, Zoology, received first choice with Physics, second series, a close second to the

animals; and plants received second choice, with Physics third.

Consideration of certain relationships existing between progress in subject matter by a certain method. Table LXIII shows the relationship between progress in physics, botany and zoology by a class of 25 general science pupils with a reading age of 189.9, by the lecture, book and demonstration methods of teaching.

TABLE LXIII

Showing the relation between progress in Botany, Physics and Zoology by each of three methods, book, lecture and demonstration. Class of 25, A9 general science pupils with an average reading age of 189.9 according to the Stanford achievement test, form B.

	r	PE
Book Method		
Physics-Botany	.86	.036
Physics-Zoology	.70	.073
Botany-Zoology	.73	.077
Lecture Method		
Physics-Botany	.65	.08
Physics-Zoology	.11	.13
Botany-Zoology	.39	.01
Demonstration Method		
Physics-Botany	.28	.12
Physics-Zoology	.44	.04
Botany-Zoology	.15	.13

Table LXIII should be read: The relation between success in Physics and success in botany by the book method is shown by the coefficient of correlation of .86, while by the lecture method it is only .65 and by the demonstration method .28, etc.

Table LXIII shows the coefficient of correlation, between progress in physics and botany, by the book method, to be .86 with a probable error of .04, which would indicate that the ability to succeed in physics by the book method was identical with the ability to succeed in botany by the same method. The coefficient of correlation for physics and zoology and botany and zoology is .70 and .73 respectively, which shows the same significant relationship.

In the case of the lecture method the coefficient of correlation for physics and botany is .65 with a probable error of .08, which is significant, but for physics and zoology it is only .11 with a probable error of .13 showing obviously no agreement at all. The coefficient of correlation between botany and zoology by the lecture method is .39 and the probable error .01. This would indicate that there is reasonable certainty of agreement between success in botany and zoology by the lecture method.

In consideration of the coefficient of correlation between success in subject matter by the demonstration method, we find for

physics and botany and botany and zoology, practically no agreement at all, but for physics and zoology a reasonable high agreement by the demonstration method. This would show that there are comparable elements involved in the mastery of physics and zoology by the demonstration method whereas in physics and zoology by the lecture method the same elements or comparable elements essential to mastery of subject matter are not necessarily involved. The same reasons may be assigned for the low correlation between botany and zoology by the demonstration method.

Consideration of certain relationships between progress made by the three methods of teaching in each of three types of science content. Table LXIV shows the coefficient of correlation between success of a class of 25, A9 pupils in General Science, by the book, lecture and demonstration methods of teaching Physics, Botany and Zoology. Table LXV shows the correlation between success of a class of 112, A9. pupils in General Science, in each of these types of content by three methods of teaching.

TABLE LXIV

Showing the relation between progress made by the book, lecture and demonstration methods in each unit of content by a class of 25, A9. pupils in General Science with an average reading age of 189.9 according to the Stanford Achievement Test, Form B.

	r	PE
Physics		
Lecture-Demonstration	.057	.13
Book-Demonstration	.28	.13
Book-Lecture	.57	.091
Botany		
Lecture-Demonstration	.24	.13
Book-Demonstration	.61	.089
Book-Lecture	.63	.086
Zoology		
Lecture-Demonstration	.055	.13
Book-Demonstration	.23	.13
Book-Lecture	.18	.13

Table LXIV shows a zero correlation between success by the lecture and demonstration methods in physics and a negative correlation between success in zoology by the same methods. Success in botany by the book and lecture methods appears to be the only significant positive correlation. The rest are either very low, zero or negative, indicating that there are very limited identical elements involved, or no comparable elements present, or even an inverse relation with reference to the elements involved in success by several methods in subject matter.

TABLE LXV

Showing the relation between progress made by the book, lecture and demonstration methods in each unit of content by a class of 112, A9. pupils in General Science with a reading age of 185 according to the Stanford Achievement Test, Form B.

	r	PE
Physics		
Lecture-Demonstration	.037	.06
Book-Demonstration	.50	.05
Book-Lecture	.22	.06
Botany		
Lecture-Demonstration	.44	.05
Book-Demonstration	.09	.05
Book-Lecture	.17	.067
Zoology		
Lecture-Demonstration	.18	.06
Book-Demonstration	.25	.06
Book-Lecture	.44	.05

Table LXV should be read: The relation between success in physics by the lecture and demonstration methods is .037, in botany it is .44 and in zoology .18, etc.

Table LXV shows a zero correlation between progress by the lecture and demonstration methods used in teaching physics, and between progress made by the book and demonstration methods in botany.

There appears to be a reasonable high correlation between success in zoology by the book and lecture methods; between success in botany by the lecture and demonstration methods and success in physics by the book and demonstration methods. One might conclude that to succeed in botany by the book method is no criterion for assuring success in the same subject by the demonstration method, whereas if the content were physics, success might be expected by both methods.

Consideration of the relationship between reading ability and success in three types of content, botany, physics and zoology. Table LXVI shows the relationship between reading ability, as measured by the Reading Examination of the Stanford Achievement Test, and success in physics, botany and zoology by a certain method.

With 148 pupils taught botany by the book method we find a low correlation between their reading age and success in botany. A zero correlation was found between the reading ability of 56, A9. pupils and success in physics by the book method, and a negative correlation between the reading ability of 136, A9. pupils and success in zoology by the book method. A zero corre-

lation was found between reading ability and success in physics by the lecture and demonstration methods. On the whole, there appears to be no significant relationship between reading ability and success in science subject matter by any method.

TABLE LXVI

Showing the relation between reading ability as determined by the Stanford Achievement Test, and progress in each type of content, physics, botany and zoology, by a certain method.

	Number of cases	r	PE
Book Method			
Botany	148	.14	.05
Physics	56	.0058	------
Zoology	136	−.001	------
Lecture Method			
Botany	93	.16	.07
Physics	170	.036	.023
Zoology	93	−.24	.02
Demonstration Method			
Botany	151	.18	.05
Physics	149	.072	.06
Zoology	152	.26	.05

Consideration of predictive value of success attached to the relationship between reading ability and scores made in the initial tests of three types of science content. Table LXVII shows the relationship between reading ability and success in the initial tests in botany, physics and zoology.

TABLE LXVII

Showing the relation between reading ability and success in each type of content. Using initial scores for content. Average R. A. 188.

	Number of cases	r	PE
Zoology	122	.36	.05
Botany	121	.27	.06
Physics	115	.24	.06

Table LXVII should be read: The relation between what pupils know about zoology before taking the course and their ability to read subject matter is shown by the correlation .36 in zoology, .27 in botany, etc.

Table LXVII shows a coefficient of correlation between ability to read, as determined by the Reading Examination of the Stanford Achievement Test, and success in the initial test of zoology, of .36 with a probable error of +.05 for 122 cases, in the initial test of botany of .27 with a probable error of +.06 for 121 cases, and in the initial test of physics of .24 with a probable error of +.06. Their findings indicate a positive relationship

between ability to read general reading material of an unselected character and mastery of such elements of scientific content as would be reflected in objective tests of a scientific character.

CHAPTER V

SUMMARY AND CONCLUSIONS

1. The study of methods of teaching science in the high school has been confined to an attempt to discover the relative effectiveness of the laboratory and demonstration methods, or the laboratory and lecture methods. In a few investigations an attempt was made to determine the relative values of the lecture, text-book and other methods of teaching science. With few exceptions the groups used in the investigations were small and few in number, and frequently the subject material used in the experiment was not representative.

2. The experiments in the past, which attempted to determine the relative value of methods, were completed in so brief a period of time that pupils encountered difficulty in making adequate adjustments to each method. The conclusions based upon such a short period of experimentation can hardly be convincing.

3. The number of teachers involved in most of the experiments was limited, so that the factor of subject or method preference was ever present, as were certain personality factors.

4. In nearly all of the experiments reviewed, the conclusions were based upon final scores for both immediate and delayed recall. No consideration was given to progress scores.

5. No attempt was made, save one, to determine by questionnaire, or otherwise, pupil preference with regard to method or subject matter.

6. The present study was an attempt to determine the relative merits of three methods of teaching general science in the high school, viz. the lecture, textbook and telling-demonstration methods.

7. Three distinctive factors were emphasized by these methods, in the mastery of three types of content in general science. These factors were: self-mastery, without teacher-aid —the so-called book method; mastery through lecture and

demonstration by the teacher—so called lecture method; and lastly, mastery involving both teacher and pupil participation—so called telling-demonstration method.

8. Twenty-two, A9. general science classes were selected for the study, from junior and senior high schools, and taught by sixteen teachers.

9. The average chronological age for the total group was 15.2 years, and it happened that the average chronological age for the boys and the girls, taken separately, was also 15.2 years.

10. The average reading age, as determined by the Reading Examination, Form B. of the Stanford Achievement Test, was 15.2 years, and the average I.Q. as determined by the Terman Group Test of Mental Ability was 98.3.

11. Three types of content were selected from Snyder's General Science Text, a text used by all classes the previous semester. The types were: botany, physics and zoology. Each type of content was divided into three units requiring three days of teaching for each unit by a particular method, this covering a period of nine weeks for the entire experiment.

12. Objective tests were prepared for initial and final test for each unit of content. The final test for each unit being repeated as a retention test three weeks after it was used to test immediate recall.

13. The reliability of the initial and final tests for each of the three types of content was determined by giving the initial and final tests of botany to one hundred high school pupils studying botany and was found to be, $.66 \pm .05$. The reliability of the initial and final tests of physics was established by giving the tests to ninety-five high school pupils studying physics and was found to be, $.63 \pm .07$. The reliability of the initial and final tests for zoology was established in the same manner as that of botany and was found to be, $58 \pm .04$.

14. The results obtained from the tests were changed into percent scores for the initial, final and retention tests. The progress scores were derived from the difference between the final and initial scores in percent, and the retention-progress scores were derived from the difference between the retention final scores and the initial scores in percent.

15. Mean scores were used for comparison of methods and the true difference of the mean scores was established by the probable error of the difference of the mean scores.

16. The comparison by mean scores was considered significant

when the ratio of the difference of the mean scores in percent to the probable error of the difference of the mean scores was equal to, or greater than 2.5.

17. The statistical measures used for the purpose of analysis and evaluation of test materials were in all cases standard devices.

18. Comparisons of methods on different achievement levels were made by means of percentile scores.

19. Factors relative to the condition of the room, atmospheric conditions, temperature, etc., which would affect pupil comfort during the progress of the experiment, were carefully noted.

20. Pupil preference with regard to subject matter and methods used was recorded by means of questionnaire.

21. The character of teacher training, experience and preference in teaching the types of science included in the experiment were determined by means of a questionnaire.

The following are some of the conclusions that may be drawn from the study:

1. The use of the final test scores as a basis for determining the relative merits of three methods of teaching science would give preference to the lecture method over the other two in botany, and to the demonstration method over the other two in physics and zoology with the book method second rank.

2. When the means of the progress scores are employed as a basis for comparison of methods, the demonstration method receives first choice with the lecture method second, as contrasted with the lecture method which was preferred as first choice and the book method second when merely final scores were considered.

With regard to the comparison of method in physics and zoology, no preference was given as to method when progress scores were considered as contrasted with the preference given to the demonstration method over the other two when merely final scores were considered.

3. No preference was given with regard to method by the retention scores, as contrasted with preference being given to the demonstration method when retention-progress scores were used for comparison. The means of the retention scores used in the comparison of methods in physics gave total preference to the demonstration method as contrasted with no preference being given to any one method when the means of the retention-progress scores were considered.

In zoology the order of preference of method was, demonstration, book and lecture as contrasted with no preference given to method when the retention-progress scores were considered.

4. In consideration of the total preferences with regard to methods for the three series of content, general science, the order of rank of methods for the means of the final scores is, demonstration, book and lecture; and for the progress, retention and retention-progress scores it is, demonstration, lecture and book.

5. When the percentile final scores on tests are taken as the measure of evaluating the relative merits of the three methods employed in the study it is found that no preference is given with regard to method in the upper quartile as contrasted with preference given to the demonstration method in the upper quartile when the percentile progress scores are used as the basis for evaluation.

The upper quartile gives preference to the demonstration method over the other when both the final and progress are considered, and second choice is given equally to the other two methods in the upper quartile when both the final and progress scores are considered.

For the middle fifty per cent the demonstration method is given preference over the other two when the percentile final scores are considered as a basis for evaluation, with equal choice given to the other two methods for second place. When the percentile progress scores are considered for the middle fifty percent preference is also given to the demonstration method but second choice is given to the book method.

6. When percentile retention scores are considered for comparison of methods in the lower quartile, the order of rank of methods is demonstration first, with no choice for second place, and in the upper quartile the order of rank of method is, demonstration, lecture and book. Considering the middle fifty percent the order of rank is, demonstration, with equal value assigned to the book and lecture methods for second place.

When the percentile retention-progress scores are considered in the lower quartile, preference is given to the demonstration method with second choice to the lecture method, as contrasted with no second choice when the percentile retention scores were considered.

In the upper quartile, preference is given to the demonstration method with second place assigned to the book method, as con-

trasted with second choice being assigned to the lecture method when the percentile retention scores were considered.

7. From the findings, relevant to the comparison of methods by several measures, we may conclude that mastery of subject matter in general science requires more than merely a textbook, however well written or illustrated, or even enriched by suggested lists of experiments to be performed, or supplementary reading to be read by the pupils. The average child, in order to make the best progress in the mastery of general science, must be directed in his study by the teacher through teacher demonstration combined with discussions by both teacher and pupils.

8. The consistency of the reliability of the difference of the measures used in comparison of methods, demonstrated the fact that teaching certain science content by a certain method showed differentiation between groups; that the differentiation was more pronounced by one method than another and in one subject than another, as for example: the effect of the demonstration method in physics content was greater in comparison with other methods than in botany content; and even greater in the third unit of zoology than in the second or first units of zoology. In botany content the demonstration method shows a decided preference over the other methods for all groups for immediate recall and for retention. In physics content, for both immediate recall and retention, the demonstration method is superior except in the second unit where the lecture method is superior, but the difference is not reliable. In considering zoology content we can safely say that the demonstration method is also superior to the other two, for both immediate recall and retention. In only four instances in the three types of content is the lecture method superior to the demonstration with statistical certainty. In seven out of a possible fifty-four chances, is the book method superior to either the demonstration method or the lecture method thus making the lecture method a safe second choice for all three types of content for both immediate recall and retention.

9. According to the findings on the basis of the questionnaire submitted to all pupils participating in the investigation, with regard to choice of subject matter used in this study, 114 girls ranked animals as their first choice, and 147 boys ranked electricity as their first choice. The total combined choices for both boys and girls gave animals first choice, plants second choice and light third choice.

10. Only 81 pupils ranked the book method as first choice, whereas 215 pupils ranked the demonstration method as first choice, and 172 pupils ranked the lecture method as first choice; 182 pupils gave second preference to the lecture method and 248 pupils gave the book method as their third choice.

It is obvious therefore, that the order of rank of method, according to pupil preference, is, demonstration, lecture and book.

11. Forty-nine percent of the pupils regarded the course in general science as the most helpful of the subjects pursued during the semester. This fact would lead to the conclusion that nearly half of the pupils, taking the course, consider it of greater value to them than any one or all of the other subjects, which leads to the further conclusion that the most effective method of teaching should be employed by the teacher to insure a maximum of progress by the pupils.

12. There appears to be a high positive correlation (.86) between success in physics and success in botany by the book method, and an equally high correlation between success in physics and success in zoology (.70) by the same method. The correlation between success in botany and success in zoology is $.73 \pm .07$. All of which would show that similar elements must be involved in the mastery of subject matter in general science by the book method. When we consider the results of the lecture method, we find a lower correlation between success in physics and success in botany than by the book method, and approximately zero correlation ($.11 \pm .13$) between success in physics and success in zoology by the lecture method as contrasted with a high correlation by the book method. The coefficient of correlation between success in botany and success in zoology by the lecture method was ($.39 \pm .01$) as contrasted with ($.73 \pm .07$) by the book method.

We can conclude from these findings then, that a much less significant relationship exists between success in one subject with success in another subject by the lecture method than by the book method.

When we consider correlations between success in subject matter by the demonstration method, we find that the coefficient of correlation between success in physics and success in botany is much less ($.28 \pm .12$) than that found by the lecture and book methods, and that the correlation between success in physics and success in zoology by the demonstration method is ($.44 \pm .44$)

and greater than that of the lecture method, but less than that of the book method. The correlation between success in botany and success in zoology, ($.15 \pm .13$) by the demonstration method is not significant and is less than that found by the other two methods.

We might conclude from these findings that mastery of physics and zoology content by the lecture method is not as easy for the average child as by either the book or demonstration methods, and the mastery of botany and zoology may best be expressed by the book method.

13. In consideration of the relationship between success by one method, and success by another method in physics or botany or zoology, we find a negative correlation between success in physics and zoology by the lecture method, and success in the same subjects by the demonstration method, and a low correlation for botany ($.24 \pm .13$) between the same methods.

Significant correlations are found in physics and botany between success by the book and success by the lecture methods, ($.57 \pm .09$), ($.63 \pm .09$), and a coefficient of correlation of $.61 \pm .09$ is found in botany between success by the book and success by the demonstration methods.

We might conclude then, that the maximum of success in physics may be best obtained by the book and lecture methods, and in botany the book and lecture methods, and in zoology by the book and demonstration methods.

14. In consideration of the relationship that exists between reading ability and success in botany, physics and zoology by a certain method, we find a negative correlation between reading ability and success in zoology by the book and lecture methods, and zero correlation between reading ability and success in physics by the book and lecture method. A very low correlation is found between reading ability and success in botany by all three methods.

The results would indicate that success in subject matter is found in general science is not based upon ability to read as determined by a standard reading test. This may be due to the fact that a general reading test contains very little reading material of a scientific character, and it may be partly due to the fact that pupils gain much information from demonstrations, charts and maps, which appear on the teachers' tables, on the walls and in the textbooks.

15. It is obvious that the selection of three types of content,

and the division of it into three units of this study, made it possible for a longer exposure, by pupils to each type and for each method so that the results obtained for botany, physics and zoology by each method were more conclusive and convincing. This fact is borne out by the variation of the effect of method within each type of content. For example, if the second unit of zoology, or the third unit of physics had been the only units for the two subjects, the order of rank of methods would have been changed entirely for physics and zoology.

16. It is also very obvious that the employment of progress scores as a basis for evaluation of the test results has proved most effective in determining the relative merits of the three methods, both for immediate recall and for retention, since the findings by these measures were consistent for immediate and delayed recall, whereas the final scores failed completely in this respect.

17. The fact of using a large number of classes made it possible to vitiate pupil preference with regard to subject matter and method.

18. The matter of teacher training, teacher experience and teacher preference, with regard to method and subject matter had no preferential effect upon methods used in the study since there were sixteen teachers employed in the study, and they were nearly equally divided as to training and experience in each of the three types of science involved in the study.

19. Since the initial scores for each unit of content indicated differentiated groups on the basis of information gained by one method or another, it is safe to conclude that final scores are not reliable criteria for the determination of progress made by a certain method. Hence, for the purpose of determining consistent growth of a group, and especially of individuals in the group, progress scores seem to be the only safe measure.

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